

ANALYSIS OF AIR TOXICS COLLECTED AS PART OF THE JOINT AIR TOXICS ASSESSMENT PROJECT

**FINAL REPORT
STI-905039.03-3016-FR**

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**Prepared for:
Arizona Department of Environmental Quality
Phoenix, AZ**

December 2006

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1. OVERVIEW

The Joint Air Toxics Assessment Project (JATAP) is a consortium of federal, state, local, and tribal air pollution control officials designed to address the risk from air toxics in the greater Phoenix Metropolitan area. Participants include the U.S. Environmental Protection Agency (EPA) Region 9, the EPA Office of Air Quality, Planning, and Standards (OAQPS), Arizona Department of Environmental Quality (ADEQ), the Maricopa County Environmental Services Division, the Pinal County Air Quality Control District (PCAQCD), the Intertribal Council of Arizona, the Gila River Indian Community (GRIC), the Salt River–Pima Maricopa Indian Community (SRPMIC), and the Fort McDowell Yavapai Nation. The purpose of the study is to determine which air toxics are of most concern to South Phoenix and tribal communities. The measurements made in 2005 are the second phase of the study. Phase I consisted of air toxics measurements at the South Phoenix and West 43rd Avenue sites from August 2001 through March 2004 (McCarthy et al., 2004a). The ultimate goal of this consortium is to obtain a metropolitan-wide assessment of the risk associated with airborne toxics in greater Phoenix.

Currently, 188 hazardous air pollutants (HAPs), or air toxics, regulated by the federal Clean Air Act have been associated with a wide variety of adverse health effects, including cancer, neurological effects, reproductive effects, and developmental effects (U.S. Environmental Protection Agency, 2000). Air toxics are emitted by a range of anthropogenic sources such as automobiles, commercial and retail entities, and industrial sources. Air toxics monitoring data are needed to characterize ambient concentrations in representative areas (i.e., at regional levels) to support and evaluate dispersion modeling efforts, and to quantify trends and the effectiveness of air toxics reduction strategies (e.g., the reduction of source-specific pollutant concentrations).

For JATAP 2005, air toxics samples (24-hr average or two 12-hr samples) were collected every sixth day at five sites operated by ADEQ: South Phoenix, West Phoenix, Greenwood, Phoenix Supersite (typical urban site, National Air Toxics Trends Site [NATTS]), and Queen Valley (background/downwind site). The SRPMIC collected air toxics samples at its Senior Center site, and the GRIC collected air toxics samples at its St. Johns site. Air toxics samples were also collected at Fort McDowell, but were assessed separately. ADEQ contracted with Sonoma Technology, Inc. (STI) to validate and assess gaseous air toxics data collected from January 2005 through January 2006. The sites are shown in **Figure 1-1**. Monitoring details and objectives are provided in **Table 1-1** (Sundblom et al., 2006).

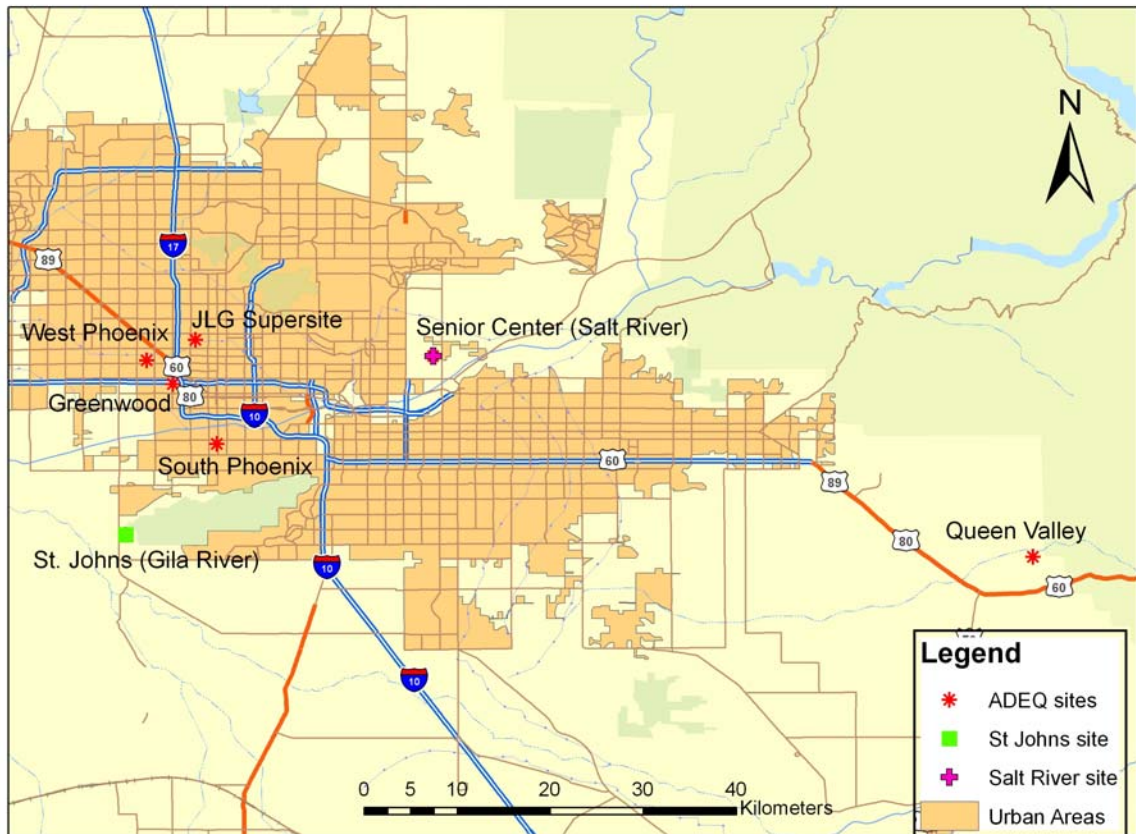


Figure 1-1. Monitoring sites contributing data to JATAP 2005 and discussed in this report.

Table 1-1. Monitoring details and sampling objectives for JATAP 2005.

Location	Measurements	Sampling Frequency	Objective
Phoenix - JLG Supersite	VOCs, PAHs, carbonyls, continuous BC, continuous ECOC, continuous NMHC, PM metals	1 – 24-hr Sample Every 6 Days	Population Exposure
	Collocated VOCs, carbonyls, PM metals	1 – 24-hr Sample, Schedule Varies by Sample Type	Quality Assurance
West Phoenix	VOCs, PM metals	1 – 24-hr Sample Every 6 Days	Population Exposure
South Phoenix	VOCs, carbonyls, PM metals	1 – 24-hr Sample Every 6 Days	Population Exposure
Gila River Indian Community, St. Johns	VOCs, PM metals	Sampling Every 6 Days, Alternate 2 - 12-hr Samples and 1 – 24-hr Sample	Transport/ Gradient
Salt River Pima-Maricopa Indian Community, Senior Center	VOCs, PM metals	Sampling Every 6 Days, Alternate 2 - 12-hr Samples and 1 – 24-hr Sample	Transport/Gradient
Fort McDowell Yavapai Nation	VOCs	1 – 24-hr Sample Every 12 Days	Transport/Gradient
Greenwood, SW Corner of I-10/I-17	VOCs, carbonyls, PM metals	1 – 24-hr Sample Every 6 Days	Maximum Concentration
Queen Valley	VOCs, EC, PM metals	1 – 24-hr Sample Every 6 Days	Background

Volatile organic compounds (VOCs), organic and elemental carbon (OCEC), particulate matter (PM), nonmethane hydrocarbon (NMHC), black carbon (BC)

The three primary tasks for STI in this data validation and analysis project were to (1) validate the 2005 gaseous air toxics data (Section 2), (2) analyze gaseous air toxics data collected as part of JATAP in 2005 (Section 3), and (3) interpret and communicate the results (this report). STI previously validated and analyzed the gaseous air toxics data collected in 2003-2004 at ADEQ sites (Hafner et al., 2004; McCarthy and Hafner, 2004) and GRIC sites (McCarthy et al., 2004b) as part of JATAP.

2. DATA VALIDATION

This section summarizes the available data from 2005 and the validation findings. Additional details were provided in a technical memorandum dated May 10, 2006.

2.1 DATA AVAILABILITY

Due to physical and chemical differences in air toxics, multiple sampling and analytical methods are necessary to characterize their concentrations in the atmosphere. Gaseous air toxics such as benzene and formaldehyde were the focus of the JATAP project, rather than particulate matter (PM) metals such as arsenic or chromium VI, or semivolatiles such as chrysene or fluoranthene.

Two methods were used to collect gaseous air toxics in the Phoenix area for JATAP: stainless steel canisters and dinitro-phenyl hydrazine (DNPH) cartridges. Canister samples were used to collect a variety of hydrocarbons and chlorocarbon compounds; these canisters were analyzed by Environmental Analytical Services (EAS) or the San Diego Air Pollution Control District (SDAPCD), depending on the site (see **Table 2-1**). A subset of canister samples were also analyzed by the EPA Region 9 laboratory for quality assurance (QA) purposes. Cartridges were used to collect a set of oxygenated hydrocarbons known as carbonyl compounds (e.g., formaldehyde and acetaldehyde) at South Phoenix, JLG Supersite, and Greenwood. **Table 2-2** lists the sites where analysis was complete as of November 2006. Samples were analyzed using a number of methods (as summarized in Table 2-2).

Data were supplied to STI electronically by EAS, SDAPCD, and the EPA Region 9 laboratory and were then assessed and validated as part of this task. SDAPCD delivered the canister data collected at JLG Supersite, Queen Valley, and Greenwood; however, the data reported with dates after October 2005 have not been completely quality assured by the laboratory.

Extensive data processing was required to convert data into a standardized format. Ambient concentration, log sheet, and laboratory sheet data were combined in a database. Canister numbers listed on sampling and analytical log sheets were checked to ensure the correct sample was associated with the correct date and time.

Table 2-1. Analysis methods used for data collected at JATAP sites in 2005.

Site	Sampling Method	Analysis Method	Laboratory
Greenwood	Cartridges	TO-11	EAS
	Canisters	TO-15	SDAPCD
JLG Supersite	Cartridges	TO-11	SDAPCD
	Canisters	TO-15	SDAPCD
Queen Valley	Canisters	TO-15	SDAPCD
St Johns	Canisters	TO-15	EAS
Senior Center	Canisters	TO-15 TO-15 SIM	EAS
South Phoenix	Cartridges	TO-11	SDAPCD
	Canisters	TO-14 TO-15 TO-15 SIM	EAS
West Phoenix	Canisters	TO-14 TO-15 TO-15 SIM	EAS

TO-15 = gas-chromatograph mass-spectrometer (GC-MS)

SIM = Selective Ion Monitoring

TO-14 = GC-flame ionization detection (FID)

TO-11 = high performance liquid chromatography (HPLC) with ultraviolet absorption

Table 2-2. List of available data collected at JATAP sites in 2005.

Site	Sampling	Sampling Duration	Samples Expected	Samples Available	Valid Samples	Percent Valid
Greenwood	Cartridges ^a	24-hr	61	60	60	98
	Canisters	24-hr	61	61	59	97
JLG Supersite	Cartridges ^a	24-hr	61	61	49	80
	Canisters	24-hr	61	61	55	90
St. Johns	Canisters	24-hr and 12-hr	30 (24-hr) 62 (12-hr)	37 (24-hr) 44 (12-hr)	79	95 ^b
Senior Center	Canisters	24-hr and 12-hr	30 (24-hr) 62 (12-hr)	37 (24-hr) 46 (12-hr)	83	98 ^b
South Phoenix	Cartridges ^a	24-hr	61	60	52	85
	Canisters	24-hr	61	60	59	97
Queen Valley	Canisters	24-hr	32	32	30	94
West Phoenix	Canisters	24-hr	61	60	59	97

^a Carbonyls only.

^b Alternating schedule was not consistent; 24-hr samples were collected in place of some 12-hr samples. This percentage is based on total number of sample days.

2.2 DATA VALIDATION APPROACH

Many air toxics are present in concentrations too low to be detected using standard analysis techniques. Species with concentrations below the reported minimum detection limits (MDLs) were tabulated for the South Phoenix and West Phoenix sites. Further validation of species with more than 75% of measurements below the MDL is difficult because we cannot easily check species relationships or time series for patterns.

Data displays—scatter, fingerprint, and time series plots—were inspected to identify problems and inconsistencies. Scatter plots enable investigation of the relationships among species at one site or at a number of sites. Fingerprint plots show the concentration of each species in a sample and help identify unique characteristics of the samples. Time series plots show the concentrations of species in every sample over a specified time period and are useful in showing the diurnal behavior of a species. Specific investigations were performed during validation of the air toxics data using VOCDat (Hafner and Prouty, 2004) and database tools:

- Quantified the percentage of measurements with concentrations above the MDL at each site.
- Inspected time series plots of every species, looking for seasonal variations, high and low values, and relationships to other species.

- Compared concentrations of species to well-characterized remote background concentrations (McCarthy et al., 2006c).
- Prepared scatter plots of VOCs that are likely to be emitted by the same source and that typically correlate well, including benzene and acetylene, the xylene isomers (o-xylene should be less than the sum of m- & p-xylenes), benzene and toluene (toluene concentrations are typically higher and toluene outliers are expected), and 1,3-butadiene and benzene.
- Inspected fingerprint plots of every sample with an emphasis on the flagged samples (based on the investigations above) and on the surrounding samples (looking for gaps in data, odd fingerprints, abrupt changes, and missing data).
- Entered comments about why quality control (QC) codes were changed when we identified samples or individual species that needed to be flagged.
- Examined duplicate analyses of samples to determine the precision of measurements, including sample collection and laboratory analysis.

2.3 VALIDATION RESULTS

This section summarizes findings, provides additional information about suspect data, and includes example plots from VOCDat that illustrate validation findings. This section should be useful to monitoring personnel interested in analytical issues and to data analysts interested in observations of unusual features in the data. The tables in Appendix A list all samples we identified as suspect or invalid and provide the reason for the QC code change.

2.3.1 MDL Summary

Species with reported concentrations below the MDL or concentrations reported as non-detects were counted by species and site. The number of samples above MDL was divided by the number of valid samples to find the percentage of each species above the reported MDL, as displayed in **Table 2-3** for cartridge species and **Table 2-4** for canister samples. Species highlighted in green have 75% or more measurements above the reported MDL. Species with 25 to 75% of measurements above the reported 2005 MDL are highlighted in yellow. Species with less than 25% of measurements above the 2005 MDL will have relatively uncertain annual average values and may be biased by a substitution; these species are highlighted in red. When such a high percentage of data are below the MDL, the MDL can be used as an upper limit on the annual average concentration (i.e., of red species). Subsequent risk assessments to understand which air toxics contribute to risk in local populations may be limited if annual averages are uncertain due to high MDLs or a low percentage of species above MDL. The species with the largest differences in percent of data above MDL between sites are 1,3-butadiene and styrene. MDL values are reported for every sample and provided in the database. One of the goals of the 2005 sampling campaign was to obtain improved MDLs compared with 2004 and this goal was met (**Figure 2-1**).

Table 2-3. The percentage of cartridge samples collected in 2005 at the Greenwood, South Phoenix, and JLG Supersite sites for each species with 24-hr or averaged 24-hr concentrations above reported MDLs.

Species	Greenwood 2005 % Above MDL	South Phoenix 2005 % Above MDL	JLG Supersite 2005 % Above MDL
Acetaldehyde	100	98	100
Formaldehyde	97	98	100

Most species had a similar percentage of samples above or below MDL at the South Phoenix, West Phoenix, and Senior Center sites, indicating that concentrations at these three sites are relatively consistent. There were two exceptions to this trend. Only 17% of 1,3-butadiene measurements were above MDL at the Senior Center compared with 78% at South Phoenix and 81% at West Phoenix. This finding is consistent with the Senior Center's proximity to roadway emissions—the traffic density near the Senior Center is much lower than that near the other two sites, and 1,3-butadiene reacts away quickly in the atmosphere. The amount of styrene data above the MDL was much lower at South Phoenix (57%) compared with West Phoenix (78%) and the Senior Center (81%). The spatial variability in styrene is difficult to explain and we found no obvious explanation.

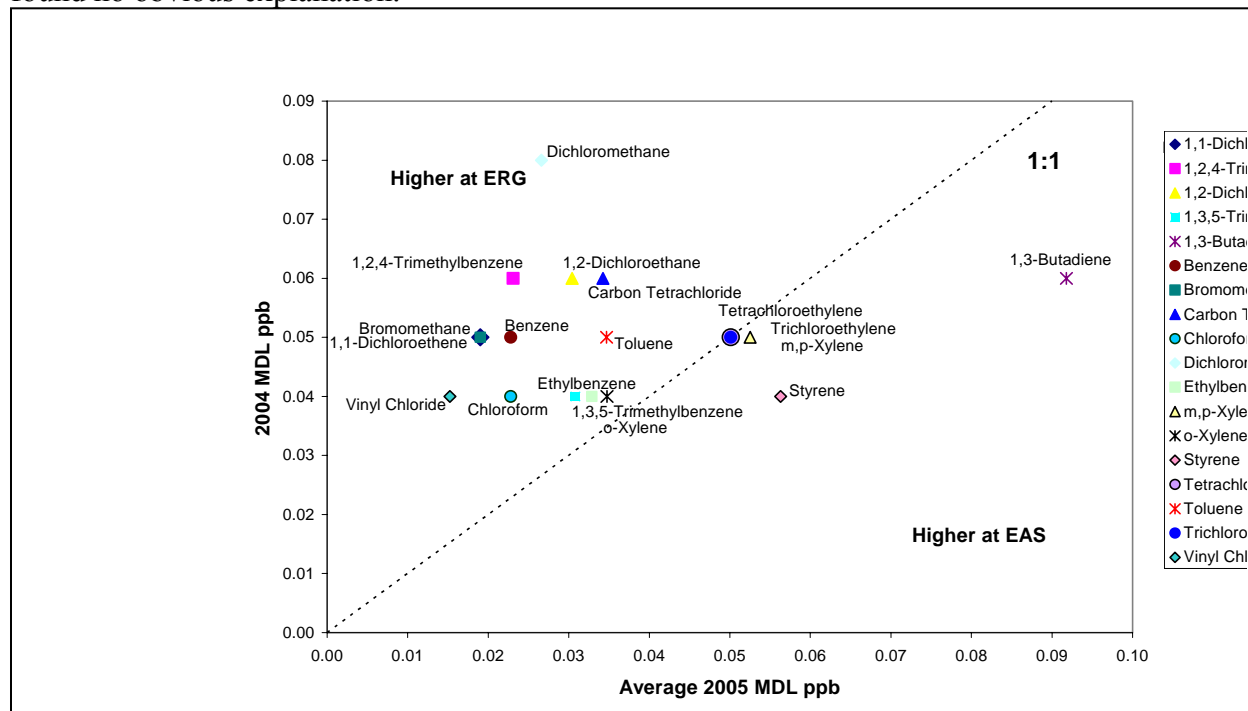


Figure 2-1. Scatter plot comparing average 2005 MDLs to 2004 MDLs by species. The MDLs of species above the 1:1 line were higher in 2004 while MDLS of those below the line were higher in 2005. MDLs of most species analyzed by EAS were lower in 2005.

Table 2-4. The percentage of canister samples collected in 2005 for each species with 24-hr or averaged 24-hr concentrations above reported MDLs.

Species	Percent Above MDL						
	St. Johns	Senior Center	South Phoenix	West Phoenix	Greenwood	JLG Supersite	Queen Valley
1,3-Butadiene	10	17	78	81	100	100	17
1,1-Dichloroethene	24	17	9	13	2	0	0
1,2,4-Trimethylbenzene	73	86	86	92	98	100	83
1,2-Dichloroethane	2	5	5	6	42	25	20
1,2-Dichloropropane	1	1	0	2	0	0	3
1,3,5-Trimethylbenzene	60	71	68	76	98	100	23
Benzene	100	99	100	100	100	100	100
Bromomethane	40	36	37	49	24	33	23
Carbon tetrachloride	89	89	89	83	100	100	100
Chloroform	43	90	77	83	98	100	53
Dichloromethane	76	94	97	98	100	100	97
Ethylbenzene	71	92	92	94	100	100	93
Hexachlorobutadiene	0	0	0	0	2	4	0
m,p-Xylene	89	96	94	97	100	100	97
o-Xylene	73	92	94	94	100	100	87
Styrene	40	89	57	78	98	100	37
Tetrachloroethene	21	30	54	63	100	100	83
Toluene	99	98	100	98	100	100	100
Trichloroethene	6	18	17	17	90	84	37
Vinyl chloride	12	1	3	3	2	0	0

2.3.2 Other Findings

Many species that were present in detectable concentrations (such as benzene, toluene, 1,3-butadiene, and xylenes) are likely emitted from mobile sources. Mobile source air toxics generally correlated well with one another as shown in **Figure 2-2**. These findings are consistent with other urban areas.

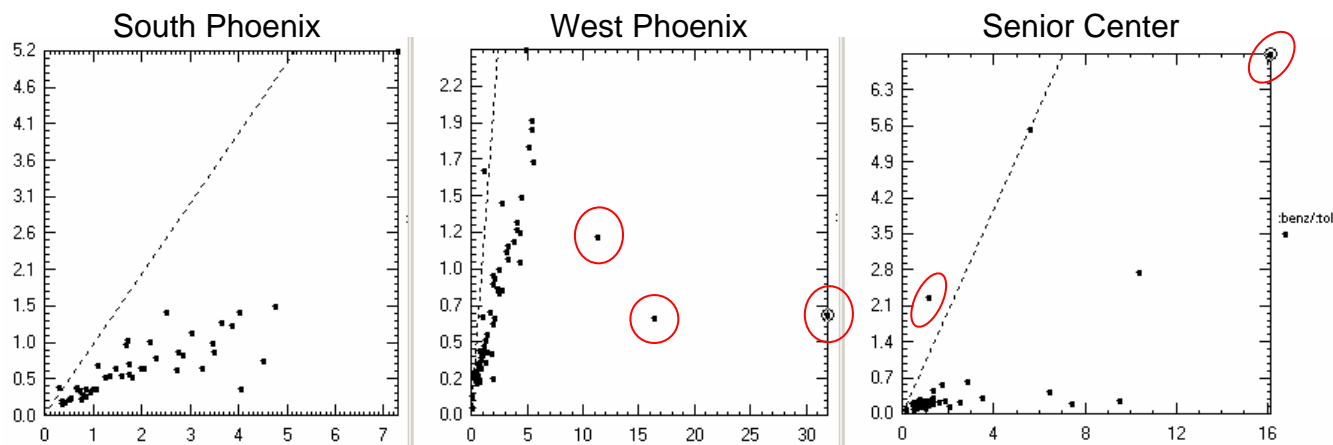


Figure 2-2. Scatter plots of correlations between benzene (y-axis) and toluene (x-axis) concentrations (ppb) at South Phoenix, West Phoenix, and Senior Center sites. These plots indicate that the species were probably emitted by the same source (i.e., motor vehicle exhaust); however, several outliers (circled in red) at West Phoenix may indicate a source that only emits toluene.

We noted that concentrations of 1,3-butadiene were higher after October 7, 2005, at the South Phoenix, West Phoenix, and Senior Center sites than in the months prior. In addition, hexachlorobutadiene detection limits were higher at the South Phoenix, West Phoenix, and Senior Center sites after October 7, 2005. This may be related to the higher 1,3-butadiene concentrations. The changes appeared to be analytical rather than outliers from a change in source emissions.

Details regarding data validation for each site are included in Appendix B. Appendix C contains a list of some of the more common gaseous air toxics and their sources in the atmosphere.

2.4 SAMPLING AND ANALYTICAL PRECISION: ANALYSIS OF COLLOCATED MEASUREMENTS, INTERLABORATORY COMPARISONS, AND ANALYTICAL METHODS COMPARISONS

Collocated (i.e., duplicate) samples were taken at the South Phoenix and West Phoenix sites at relatively regular intervals. The collocated samples were sent to EAS for analysis. Using

the collocated measurements from these two sites, we can estimate the combined analytical and sampling precision for species collected using canisters.

2.4.1 Collocated Analyses

Collocated measurements were analyzed to assess the combined sampling and analytical error in air toxics collected. Scatter plots of collocated measurements were created to examine differences in the collocated samples. Deming regressions were performed on collocated sample species to check for systematic bias and outliers.

In general, the collocated samples showed good correlations at low concentrations of air toxics. However, air toxics with high concentrations were often significantly different from the expected 1:1 relationship. For example, **Figure 2-3** shows the scatter plot of concentrations for 1,3,5-trimethylbenzene from all collocated canisters. The high outlier concentration from a sample collected March 17, 2005, is significantly above the 1:1 line. Removing this sampling date, as shown in the inset of Figure 2-3, reveals additional outliers, but the slope is less biased (slope = 0.82 ± 0.30). The March 17, 2005, samples showed that one of the two canisters was likely compromised (**Figure 2-4**).

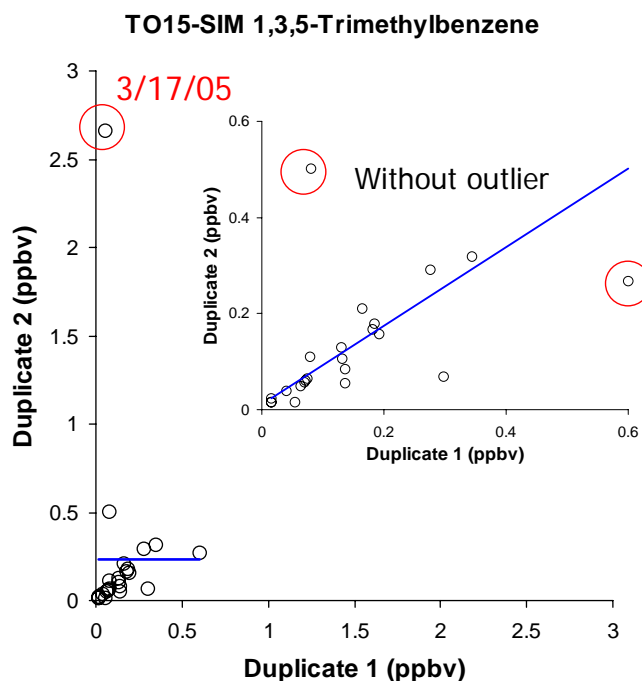


Figure 2-3. Scatter plot of collocated measurements of 1,3,5-trimethylbenzene collected at Phoenix sites. Samples circled in red are outliers.

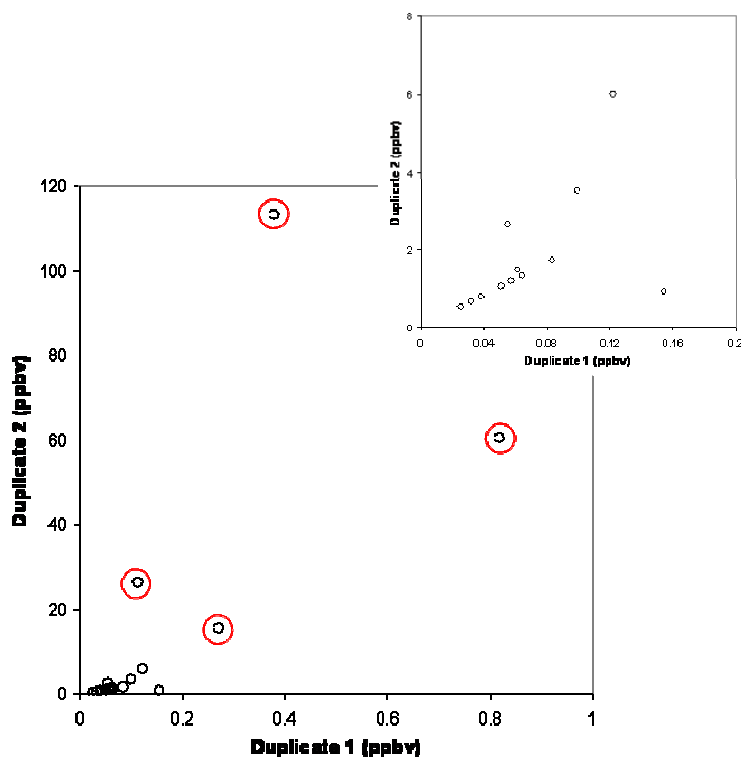


Figure 2-4. Scatter plot of collocated measurements of all species collected on March 17, 2005, at Phoenix sites. Samples circled in red are outliers. Both the main figure and the inset show that concentrations for sample 2 were a factor of 10 to 20 higher than those for sample 1.

There are multiple possible sources of imprecision in the duplicate measurements. One type of error could occur in sampling. If flow rates or pressures are not equal, we would expect a systematic bias that could alter the slope to be greater than or less than one. This is typically not the case for these samples because 75% of the slopes are within the 1.00 ± 0.15 range (when the March 17, 2005, outlier is removed). A second issue is that of analytical and sampling precision. If the slope is typically close to 1 but the standard error of the slope is high (>0.2), then the samples are likely accurate but are being imprecisely measured. The average standard error of the slope was 0.2, which is at our threshold for high imprecision. It is also possible that some of the canisters could be contaminated prior to analysis, resulting in large discrepancies in concentrations affecting only a few compounds. However, only a few sample dates appeared to be systematically biased, including the February 15, March 17, and August 27 sample dates at West Phoenix. The primary sample at West Phoenix on February 15 was flagged as suspect because of low initial canister pressure, and the March 17 primary sample was also flagged as suspect because the final canister pressure was low. In addition, although the August 27 primary sample was not originally flagged, it was noted as a sample with concentrations not typical for the West Phoenix site.

2.4.2 Interlaboratory Comparison

An interlaboratory comparison of EAS and EPA Region 9 laboratories was performed to assess possible systematic differences in concentration measurements. Eleven pairs of collocated canisters were collected at the South Phoenix and West Phoenix sites. One of each sampling pair was sent to EAS; the other was sent to the EPA Region 9 laboratory. Six toxics species were measured by each laboratory and are listed in **Table 2-5**. Scatter plots of laboratory measurements were created to examine differences. Any biases or problem species were noted. Outliers were identified visually from the scatter plots and verified statistically (i.e., found to leverage the linear regression results). Table 2-5 shows the outlier dates at South Phoenix and West Phoenix sites for samples and species measured at both EAS and EPA Region 9 laboratories.

Table 2-5. Sample outliers identified from the interlaboratory comparison of EAS and EPA Region 9.

Method	Parameter	South Phoenix	West Phoenix	Total Outliers
TO-15 SIM	Benzene	–	–	0
TO-15 SIM	Carbon tetrachloride	7/3/2005		1
TO-15 SIM	Chloroform	–	–	0
TO-15 SIM	Dichloromethane	2/27/2005		1
TO-15 SIM	Tetrachloroethene	–	12/6/2005	1
TO-15 SIM	Trichloroethene	2/9/2005, 9/19/2005, 12/6/2005	–	3

Outliers did not systematically occur on certain dates or sites or for certain species. In general, most species did not show outliers that skewed regression results. However, the slope calculated from regression of concentrations from the EAS and EPA Region 9 laboratories was outside the expected range of 1.0 ± 0.15 . Analysis showed that EAS generally measured lower concentrations than EPA Region 9 as shown in **Figure 2-5**. The precision of the measurements between laboratories appears reasonable, but the systematic differences in concentrations suggest that one of the laboratories is inaccurate. Examination of the percent recovery of internal laboratory calibration spikes revealed that the EAS laboratory recovery rate was $88 \pm 4\%$ compared with the EPA Region 9 laboratory recovery rate of $97 \pm 2\%$. Moreover, for the species that were measured by both laboratories, the difference in spike recovery rate was more than 8% higher on average. This difference suggests that measurements made by EAS are systematically biased low.

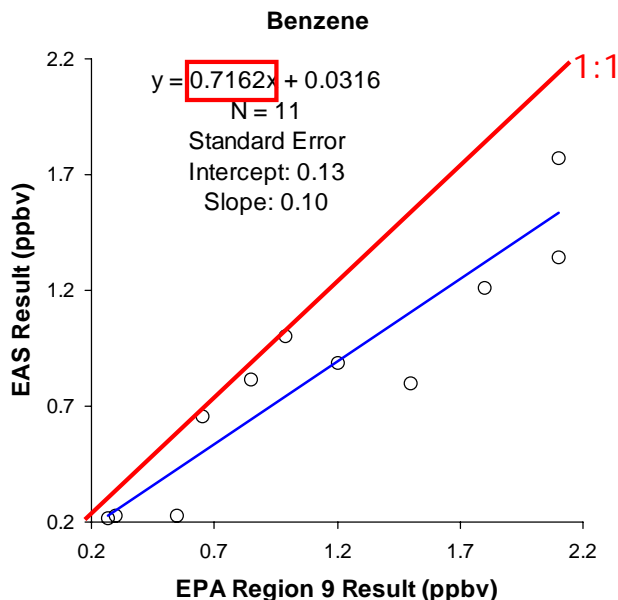


Figure 2-5. Scatter plot of benzene concentrations (ppb) analyzed at EAS and EPA region 9 laboratories. The regression slope, shown in blue, is 0.72 ± 0.03 . The red line shows the expected 1:1 slope.

2.4.3 Analytical Methods Comparison

EAS used various analytical methods for its laboratory analysis: TO-15 SIM, TO-15, and TO-14. TO-15 SIM and TO-15 both rely on mass spectrometry, but TO-15 SIM focuses on selected species for lower MDLs while TO-15 performs a full scan of species resulting in higher MDLs. TO-14 uses flame ionization detection.

MDL summaries for each method show that the percentage of data below detection was highest for TO-14 and lowest for TO-15 SIM, as shown in **Figure 2-6**. Scatter plots were created to examine differences between concentrations of species measured with more than one analytical method. TO-14 is generally a less accurate method due to the higher MDL ranges. **Figure 2-7** shows an example of the TO-14 method with a majority of concentrations reported at MDL. Because TO-14 method data are less accurate, they were only used if TO-15 or TO-15 SIM method data were not available.

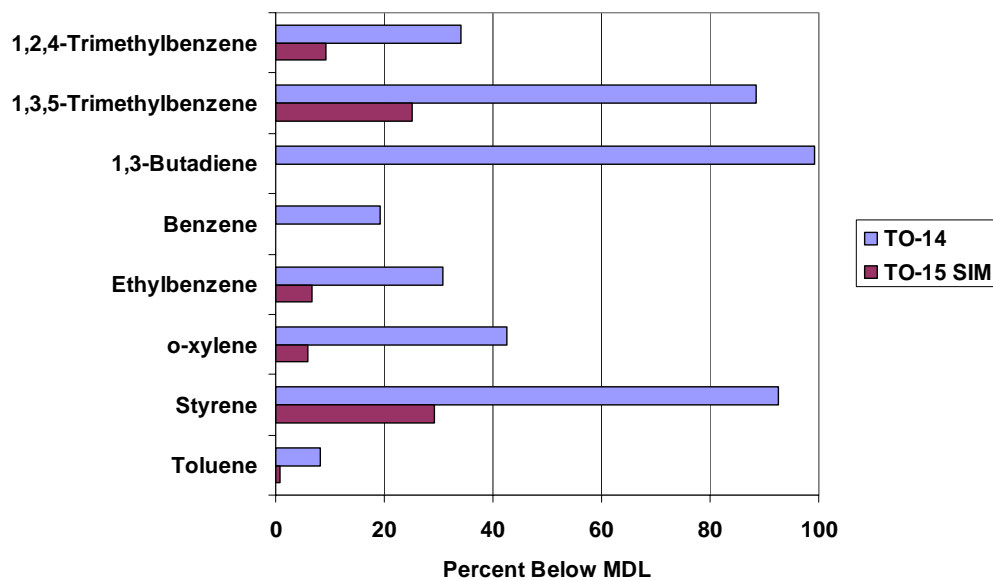


Figure 2-6. Percentage below MDL for species measured using both TO-14 and TO-15 SIM methods.

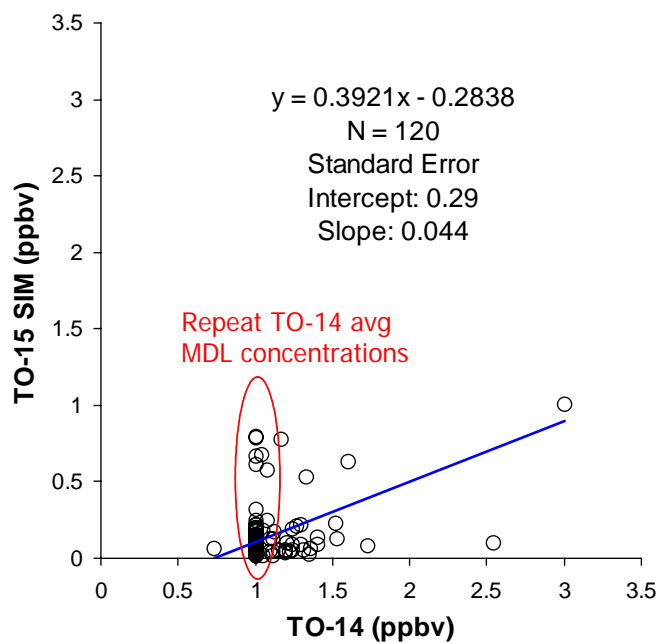


Figure 2-7. Scatter plot of styrene concentrations (ppb) made with EPA methods TO-14 and TO-15 SIM.

2.5 SUMMARY OF DATA VALIDATION

In summary, the following conclusions were drawn from the 2005 measurements:

- Data quality appeared reasonable.
- Concentrations of two-thirds of the species at all sites were above detection limits most of the time.
- Numerous carbonyl compound samples were invalidated because sample flow rates were not within acceptable limits. Low flow rates resulted from a clogged needle valve flow controller; this problem has been corrected for future measurements.
- The interlaboratory analyses showed that generally EAS measures VOC concentrations lower than EPA Region 9 by about 30%. EAS has an average blank recovery rate of $88 \pm 4\%$ versus $97 \pm 2\%$ at EPA Region 9 for the laboratory QC analysis. The blank recovery rate is consistent with the hypothesis that EAS concentrations are systematically biased low.
- Collocated measurements showed that the precision of canister species as measured by the coefficient of variation ($CV = \text{standard deviation}/\text{mean}$) was, on average, 23%. This CV is higher than the goal set for the NATTS program of 15% CV for collocated data. In total, 16 of 20 pollutants showed CVs of 15% or more.
- At the West Phoenix site, collocated samples collected on three days showed very poor correlations. This may indicate a problem with the replicate sampler at West Phoenix or, possibly, sample contamination. These collocated samples were flagged as suspect.
- EAS used TO-15 and TO-15 SIM analytical methods in 2005. A comparison of analytical methods showed that TO-15 and TO-15 SIM methods have lower MDLs and higher percentages of data above the MDL than does the TO-14 method. In addition, JATAP paid for certification of every canister, meaning an MDL was determined by sample rather than on average. Both the analytical methodology and the sample certification led to an increase in the number of species for which there are 75% or more data above MDL, compared to the results for 2003-2004 data.

Interlaboratory comparisons and collocated measurements indicate that JATAP data collected at multiple sites are likely biased low and are relatively imprecise. The systematically low bias of canister data analyzed by EAS reduces our ability to accurately characterize risk. It may be necessary to adjust data upwards to accurately characterize risk from air toxics in the JATAP area. Comparisons with data from other data sets (i.e., future years, other areas, past years) should be made with caution. Imprecision in the data will make spatial and temporal comparisons more difficult because of the larger uncertainties in the concentrations at any given site or time.

3. DATA ANALYSIS RESULTS

The goal of this task was to analyze and interpret the gaseous air toxics data collected during JATAP 2005. Numerical, statistical, and graphical analyses of the data were performed to characterize the spatial and temporal variation of the air toxics concentrations. The focus of the analyses was on air toxics with cancer benchmarks.

3.1 CAN THE AMBIENT DATA BE USED IN RISK ASSESSMENT?

One of the ultimate goals of air toxics monitoring is to assess the adverse health risk in ambient air from individual air toxics. To assess risk with confidence, average concentrations at a site must be present at levels that can either be measured accurately or determined to be below adverse health risk levels. The risk decision matrix in **Table 3-1** shows one method of assessing the suitability of ambient measurements for assessing risk. One way of determining if the risk associated with a given species can be determined with confidence is to assess how the MDL compares to both the median concentration and the cancer benchmark. If the ambient concentration and the cancer benchmark are both below the MDL, we have low confidence in their estimated risk (i.e., the pink column). We have some confidence in our ability to estimate risk for species when either the ambient average concentration and/or cancer benchmark is slightly above MDL (i.e., the yellow column). We have high confidence in the risk associated with species whose quantifiable concentrations or MDLs are well below the cancer benchmark (i.e., the green column).

Pollutants for which we have modest to good confidence in estimating risk at most sites using 2005 JATAP data included carbon tetrachloride, acetaldehyde, benzene, dichloromethane, and formaldehyde. Only hexachlorobutadiene was routinely placed in the low confidence column. Chloroform and 1,3-butadiene were on the border between the low and medium confidence columns. Better MDLs may be necessary to estimate concentrations for these pollutants.

Table 3-1. Summary of the suitability of the 2005 JATAP air toxics measurements for assessing risk.

Site	Uncharacterizable	Risk can be estimated	Risk can be quantified
Greenwood	None	Hexachlorobutadiene Vinyl Chloride Chloroform Carbon Tetrachloride Tetrachloroethene	Trichloroethene 1,3-butadiene Benzene Acetaldehyde Formaldehyde Dichloromethane
JLG Supersite	None	Hexachlorobutadiene Vinyl Chloride Chloroform Carbon Tetrachloride Tetrachloroethene 1,3-butadiene	Trichloroethene Benzene Acetaldehyde Formaldehyde Dichloromethane
West Phoenix	Hexachlorobutadiene	1,3-Butadiene Chloroform Vinyl chloride Carbon Tetrachloride Tetrachloroethene Trichloroethene	Benzene Dichloromethane
South Phoenix	Hexachlorobutadiene	1,3-Butadiene Chloroform Vinyl chloride Carbon Tetrachloride Tetrachloroethene	Benzene Trichloroethene Dichloromethane
Senior Center	1,3-Butadiene Hexachlorobutadiene	Chloroform Vinyl chloride Tetrachloroethene Trichloroethene Benzene Carbon Tetrachloride	Dichloromethane
St. Johns	1,3-Butadiene Hexachlorobutadiene Chloroform	Tetrachloroethene Trichloroethene Vinyl chloride Benzene Carbon tetrachloride	Dichloromethane
Queen Valley	Chloroform	1,3-butadiene Hexachlorobutadiene Vinyl chloride Carbon tetrachloride Benzene Tetrachloroethene	Trichloroethene Dichloromethane

3.2 PUTTING AIR TOXICS CONCENTRATIONS IN PERSPECTIVE

The following sections build on previous and ongoing analyses for the EPA regarding the national air toxics picture (Hafner and McCarthy, 2004; Kenski et al., 2005; McCarthy et al., 2006a, b; McCarthy et al., 2006c).

3.2.1 What Are Local Concentrations of Air Toxics?

Several questions about the air toxics data collected during JATAP can be answered using **Figures 3-1 and 3-2**. Of interest to the stakeholders is not only how the concentrations vary from site to site, but also how the concentrations compare with other urban areas and to cancer benchmarks. Typical urban concentrations were calculated as part of the national air toxics analysis (Hafner and McCarthy, 2004). Seasonal average concentrations from over 800 monitoring sites collected from 1990-2005 were compiled into interquartile ranges (i.e., 25th-75th percentile range). Figure 3-1 displays these interquartile ranges with the 2005 mean concentrations for the JATAP sites. Data below detection were substituted with MDL/2. Species with an asterisk (*) indicate more than 50% of data were below the MDL at some sites (see Tables 2-3 and 2-4 for specifics). Figure 3-2 is the same as Figure 3-1 with cancer benchmarks from EPA OAQPS and remote background concentrations added to the display of mean concentrations at each site. Understanding which species are present at concentrations known to exceed levels set by the EPA OAQPS, the Integrated Risk Information System (IRIS), or the California EPA can aid policy makers in regulating sources of potentially dangerous pollutants.

While inspecting Figures 3-1 and 3-2, note that less than 50% of data in the following species-site combinations was above MDL, and the annual average concentrations should be viewed with caution because they are biased by MDL substitution:

- 1,3-butadiene at St. Johns, Senior Center, and Queen Valley
- Chloroform at St. Johns and Queen Valley
- Tetrachloroethene at St. Johns and Senior Center
- Trichloroethene at St. Johns, Senior Center, South Phoenix, West Phoenix, and Queen Valley
- Vinyl chloride at all sites

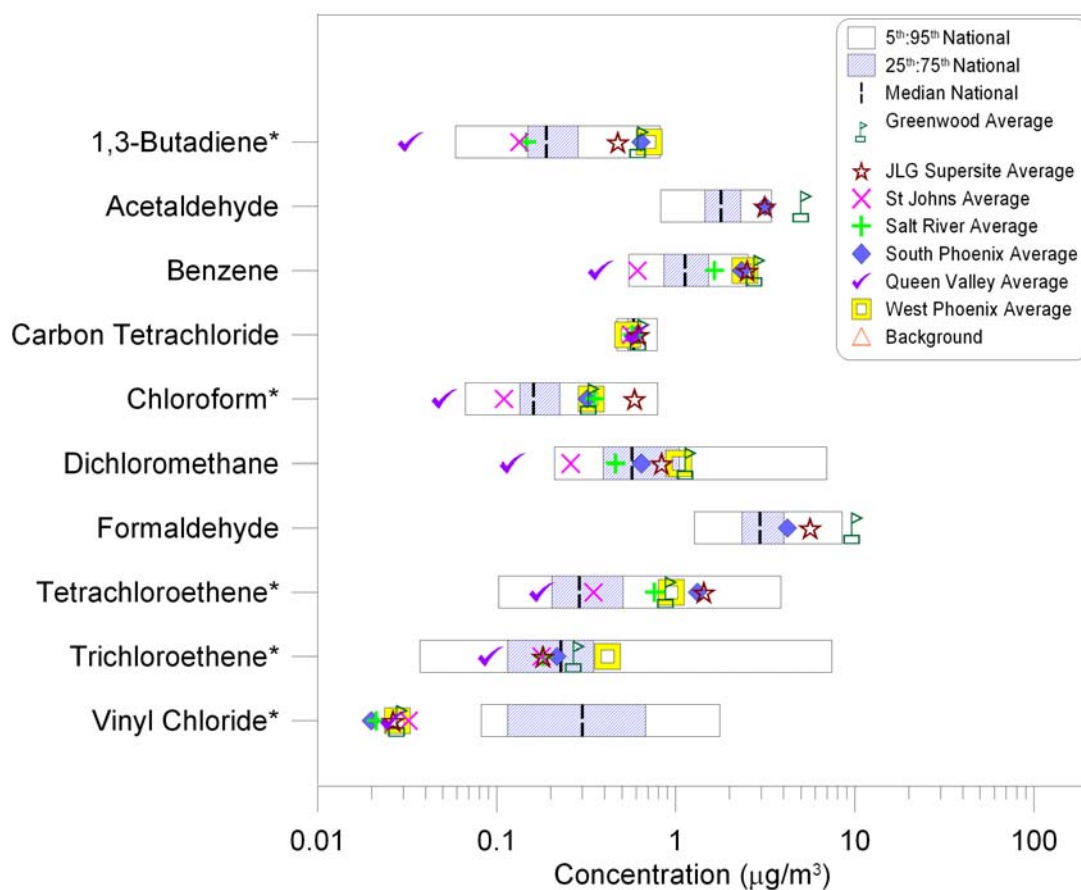


Figure 3-1. Annual average concentrations at JATAP sites (2005) compared with national concentration ranges. Species with an asterisk (*) indicate $\geq 50\%$ of data are below the MDL at some sites.

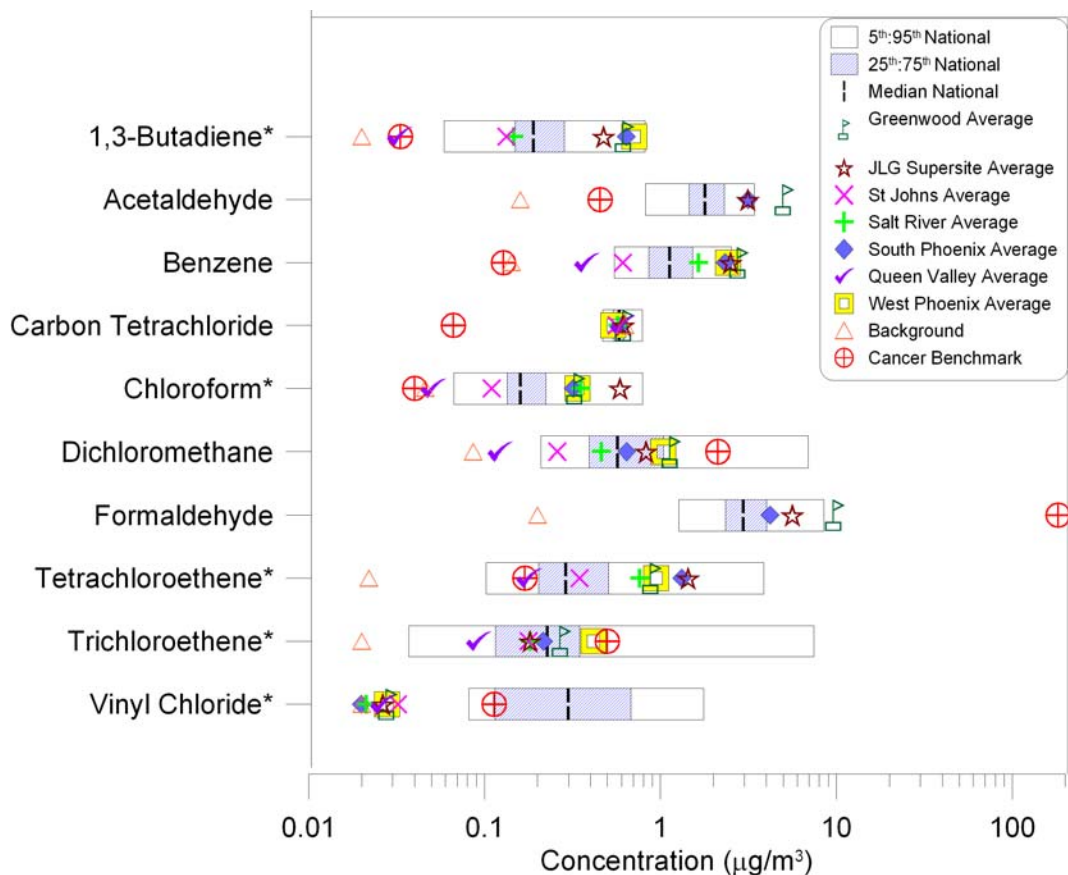


Figure 3-2. Annual average concentrations at JATAP sites compared with national concentration ranges, background concentrations, and cancer benchmarks. Species with an asterisk (*) indicate $\geq 50\%$ of data are below the MDL at some sites.

Locally, concentrations varied across the JATAP sites and concentration differences were generally consistent with proximity to emissions. As expected, sites located closer to the urban core of Phoenix (i.e., JLG Supersite, South Phoenix, Greenwood, and West Phoenix) had the highest annual average concentrations, while those located on the periphery of the urban area had lower concentrations (i.e., Salt River > St. Johns > Queen Valley). The following are specific findings:

- Greenwood carbonyl concentrations were higher than other sites; of note, concentrations were above the national urban 95th percentile. This finding may indicate additional fresh emissions at a local scale, likely from mobile sources given the location of the monitor. Carbonyl compound concentrations at South Phoenix and JLG Supersite were also high relative to other urban areas.
- Phoenix urban 1,3-butadiene concentrations were higher than concentrations at Queen Valley, St. Johns, and Senior Center sites. These three sites are located close enough to Phoenix to have been impacted by transport of air toxics from the urban core, but far

enough removed to show less influence from fresh emissions. Highly reactive air toxics, such as 1,3-butadiene, may be depleted before arriving at these sites as well.

- Benzene concentrations show a similar spatial pattern to that of 1,3-butadiene, but concentrations at the Senior Center are nearly as high as the urban sites. Benzene is removed much more slowly from the atmosphere than 1,3-butadiene and the Senior Center site is closer to a major roadway than either the St. Johns or Queen Valley sites.
- Chloroform concentrations were highest at the JLG Supersite. Concentrations at the other urban Phoenix sites were significantly higher than those at the downwind sites.

3.2.2 How Do Air Toxics Concentrations Compare with Typical National Levels?

Phoenix area urban concentrations of 1,3-butadiene, acetaldehyde, formaldehyde, chloroform, benzene, and tetrachloroethene were typically on the high end of the national urban scale (i.e., above the 75th percentile). Other air toxics concentrations were typically within the interquartile range of national concentrations (25th to 75th percentile). Note that vinyl chloride concentrations were typically below the MDL at all sites and are plotted at MDL/2.

3.2.3 What Are Background Concentrations of Air Toxics?

Background concentrations can be defined as remote or regional phenomena. Remote background is the mean concentration of a compound measured at a site not impacted by local or regional emission sources. Examples of remote sites include islands in the middle of the ocean or polar regions. These data are useful to track global scale changes in long-lived air toxics, for example. Regional background is the mean concentration of a compound measured at a site not impacted by local sources. A regional background site might be one located in a coastal area with predominantly onshore flow, or a remote continental site uninfluenced by local sources. These data are useful to help understand what is transported into an area.

Remote and rural background air toxics concentrations were compiled by McCarthy et al. (2004d). Concentrations at JATAP sites in 2005 were typically above remote background concentrations as expected. Air toxics concentrations at Queen Valley were lowest among the sites, consistent with its location far from the urban area. Air toxics concentrations at St. Johns, and sometimes at the Senior Center, were also typically on the lower end of the concentration ranges. Typical remote background concentrations contributed less than 10% of the total concentrations measured at the urban JATAP sites (Greenwood, Supersite, South Phoenix, and West Phoenix). Only carbon tetrachloride background concentrations were as high as those seen in Phoenix. Since carbon tetrachloride is a globally distributed long-lived chlorofluorocarbon (CFC), it was not surprising to see that background concentrations were responsible for 100% of the observed values at all sites.

3.2.4 Which Air Toxics Present Possible Health Risks?

Annual mean concentrations of air toxics concentrations at JATAP sites were often higher than the one-in-a-million cancer benchmark. 1,3-butadiene, acetaldehyde, benzene, carbon tetrachloride, chloroform, and tetrachloroethene concentrations were well above the one-

in-a-million risk level. **Table 3-2** lists the top five air toxics of concern based on risk-weighted annual averages at the JATAP sites in 2005. Species in the list were colored in red, yellow, or green to indicate the confidence in the assessment of each species as shown in Table 3-1.

Table 3-2. The top five air toxics of concern based on risk-weighted annual mean concentrations at JATAP sites in 2005 – numbers represent rank.

Species	Greenwood	JLG Supersite	Queen Valley	St. Johns	Senior Center	South Phoenix	West Phoenix
Benzene	1	1	2	3	2	3	3
1,3-Butadiene	2	3		4		2	2
Acetaldehyde	3						
Carbon tetrachloride	4	4	1	2	4	4	5
Chloroform	5	2	4	5	3	5	4
Tetrachloroethene		5	5		5		
Hexachlorobutadiene			3	1	1	1	1

Colors indicate the confidence in the risk estimate (green = high, yellow = medium, red = low confidence). Blank cells indicate the species was not among the five most abundant risk-weighted species for that year.

Table 3-3 lists the annual mean concentrations ($\mu\text{g}/\text{m}^3$) at each site compared with health effect levels (cancer benchmarks, noncancer reference concentrations [RfCs], and Arizona Ambient Air Quality Guidelines [AAAQG]). Typically, the AAAQG levels are within a factor of two of the cancer benchmarks. If a concentration was above the cancer benchmark, it was also usually above the AAAQG. All species were well below their RfC values at the site. Appendix D lists the top five concentrations of the pollutants in Table 3-3 by site. Appendix E contains the summary statistics for all the air toxics by site.

Hazardous air pollutants can also cause noncancer health effects, such as respiratory irritation. Reference concentrations provide an indication of levels in which chronic exposures may be of concern. For the air toxics in Phoenix, only formaldehyde at the Greenwood site exhibited concentrations that exceeded the reference concentration (see Table 3-3). All other species were below their reference concentration.

3.2.5 How Do Ambient Concentrations Compare with NATA Results?

The EPA performed a national-scale air toxics assessment (NATA) to identify and prioritize air toxics, emissions source types, and locations that are of greatest potential concern in terms of contributing to population risk. The results of the 1999 NATA are available from EPA (<http://www.epa.gov/ttn/atw/nata1999/>). The 10 most important air toxics to inhalation cancer risk in the JATAP area identified in the 1999 NATA included benzene, ethylene dibromide, 1,3-butadiene, 1,1,2,2-tetrachloroethane, carbon tetrachloride, acetaldehyde, bis(2-ethylhexyl)phthalate, naphthalene, tetrachloroethylene, and ethylene dichloride. Of these air toxics, measurements of bis(2-ethylhexyl)phthalate, naphthalene, and ethylene dichloride

were not available from the JATAP project; these air toxics are not commonly monitored across the United States.

The 1999 NATA county-level model results were compared with the 2005 annual average concentrations measured at JATAP sites (**Figure 3-3**). In comparing model to monitor concentrations, the NATA web site noted that results within a factor of two were considered to be in reasonable agreement. For the JATAP sites, acetaldehyde, benzene, dichloromethane, and trichloroethene typically agreed within a factor of two of the model consistent with national-level comparisons of model and monitor data. Carbon tetrachloride was not modeled well because the background concentrations assumed in the model were too low; chloroform modeling was similar. Ethylbenzene-, formaldehyde-, and tetrachloroethylene-monitored concentrations at the JATAP sites were more than a factor of two higher than model estimates.

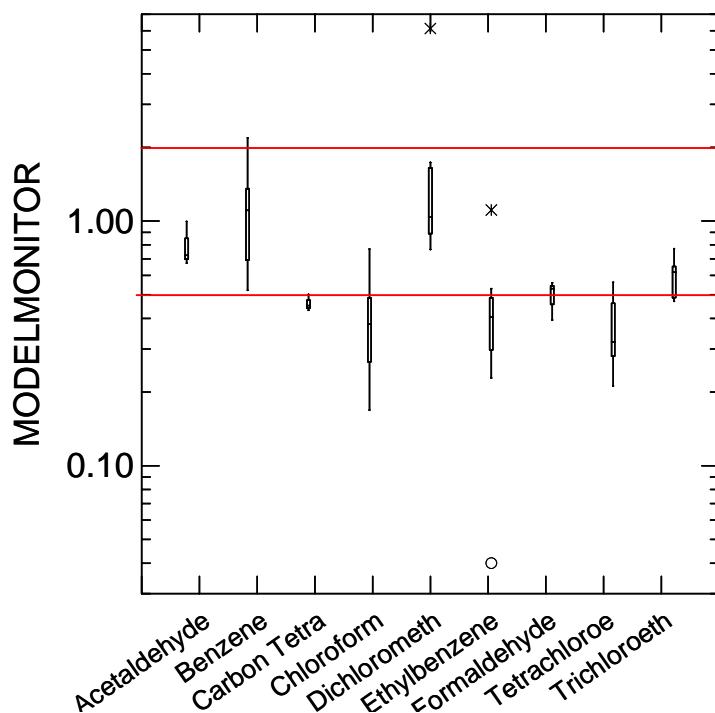


Figure 3-3. Annual average concentrations estimated by the 1999 NATA model compared with 2005 annual average concentrations at JATAP sites. County-level model results were used. Only species with more than 15% of data above detection are reported for the monitored data. Boxes show the 25th, 50th (median), and 75th percentiles. Horizontal lines at 0.5 and 2 represent agreement between the model and monitor values within a factor of two.

Table 3-3. Annual mean concentrations ($\mu\text{g}/\text{m}^3$) at JATAP sites in 2005 compared with cancer benchmarks, RfCs, and AAAQG). Species in **boldface** type indicate >50% of data are above the MDL. Concentrations for species not boldfaced should be used with caution.

Species	Greenwood Annual Mean ($\mu\text{g}/\text{m}^3$)	JLG Supersite Annual Mean ($\mu\text{g}/\text{m}^3$)	Queen Valley Annual Mean ($\mu\text{g}/\text{m}^3$)	St. Johns Annual Mean ($\mu\text{g}/\text{m}^3$)	Salt River Annual Mean ($\mu\text{g}/\text{m}^3$)	South Phoenix Annual Mean ($\mu\text{g}/\text{m}^3$)	West Phoenix Annual Mean ($\mu\text{g}/\text{m}^3$)	Cancer Benchmark ($\mu\text{g}/\text{m}^3$)	RfC ($\mu\text{g}/\text{m}^3$)	AAAQG ($\mu\text{g}/\text{m}^3$)
1,3-Butadiene	0.62	0.47	0.03	0.13	0.15	0.64	0.71	0.033	2	0.067
Acetaldehyde	5.07	3.13				3.15		0.45	9	0.5
Benzene	2.79	2.50	0.38	0.61	1.65	2.33	2.43	0.13	30	0.14
Carbon tetrachloride	0.63	0.62	0.61	0.56	0.57	0.60	0.54	0.07	40	0.036
Chloroform	0.33	0.59	0.05	0.11	0.35	0.32	0.34		98	0.043
Dichloromethane	1.15	0.83	0.12	0.26	0.46	0.64	1.04	2.13	1000	5.6
Ethylbenzene	2.06	1.61	0.82	0.37	0.71	1.12	2.38		1000	
Formaldehyde	9.81	5.61				4.20		181.8	9.8	0.08
Hexachlorobutadiene	0.11	0.12	0.11	2.26	1.91	2.49	2.91	0.05	90	0.067
m,p-Xylene	5.43	4.32	0.82	0.88	1.83	3.46	4.84		100	
o-Xylene	2.08	0.78	0.38	0.36	0.79	1.20	1.67		100	
Styrene	1.71	0.76	0.11	0.35	1.96	0.40	0.82		1000	
Tetrachloroethene	0.89	1.43	0.18	0.35	0.76	1.32	0.94	0.17	270	2.1
Toluene	8.82	7.18	0.59	2.51	7.23	6.86	12.87		400	
Trichloroethene	0.27	0.18	0.09	0.18	0.18	0.22	0.42	0.5	600	0.76
Vinyl chloride	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.11	100	0.012

3.3 CHANGES IN AIR TOXICS CONCENTRATIONS OVER TIME

3.3.1 Seasonal Variation

It is important to understand how air toxics concentrations vary by season to gain insight into source types (e.g., winter residential wood smoke versus year-round mobile source emissions) and the effects of meteorology on concentrations (e.g., differences in photochemistry and mixing heights). At all sites, concentrations of 1,3-butadiene, dichloromethane, tetrachloroethene, trichloroethene, styrene, benzene, and other mobile source-related species (e.g., toluene) were higher in the cooler months than during the warmer months. Lower mixing heights and less photochemistry likely contribute to these high concentrations more than changes in emissions for these pollutants. These findings are consistent with the pilot study ((McCarthy et al., 2004c) and with urban national-level analyses.

3.3.2 Weekday-Weekend Variation

It is important to look at day-of-week variation in air toxics concentrations to gain insight into anthropogenic source types (e.g., mobile source emissions, point source emissions). With only one year of data collected on a 1-in-6-day schedule, the confidence intervals on the median concentrations are too large to discern statistically significant differences in concentration between days. In 2005, none of the species exhibited a statistically significant weekday-weekend difference in concentration; this is consistent with previous findings.

Even when Supersite data across several years (2001-2005) were inspected, no significant day-of-week trend was evident. Our expectation was that mobile source-dominated air toxics, such as benzene, 1,3-butadiene, and formaldehyde, would display lower concentrations on weekends. However, this pattern was not observed. In locations with 1-hr or 3-hr duration samples, morning mobile source air toxic concentrations have shown declines on the weekends. It may be that over a 24-hr averaging period, there is less reduction in mobile source emissions on weekends in the Phoenix area than we anticipated.

3.3.3 Interannual Trends

A useful way to compare sites and obtain an overall understanding of the data is to inspect various stratifications of selected air toxics. In box whisker plots (an example is shown in **Figure 3-3**), the box shows the 25th, 50th (median), and 75th percentiles. The whiskers always end on a data point, so when the plots show no data points beyond the end of a whisker, the whisker shows the value of the highest or lowest data point. The whiskers have a maximum length equal to 1.5 times the length of the box (the interquartile range). If there are data outside this range, the points are shown on the plot and the whisker ends on the highest or lowest data point within the range of the whisker. The “outliers” are further identified with asterisks representing the points that fall within three times the interquartile range from the end of the box and with circles representing points beyond this.

Because we were interested in how similar or dissimilar the data are among time periods, we used an option called a notched box whisker plot to analyze data in this study (also Figure 3-3). These plots include notches that mark confidence intervals. The boxes are notched (narrowed) at the median and return to full width at the 95% lower and upper confidence interval values. If the 95% confidence interval is beyond the 25th or 75th percentile, then the notches extend beyond the box (hence a “folded” appearance). Confidence intervals are a function of sample size; small sample size will increase these intervals.

Benzene concentrations from 2001 to 2005 have remained relatively flat at the Supersite and South Phoenix site as shown in **Figure 3-4**. Other air toxics showed similar interannual trends—higher emissions in some years and lower in others—but no statistically significant change over this period.

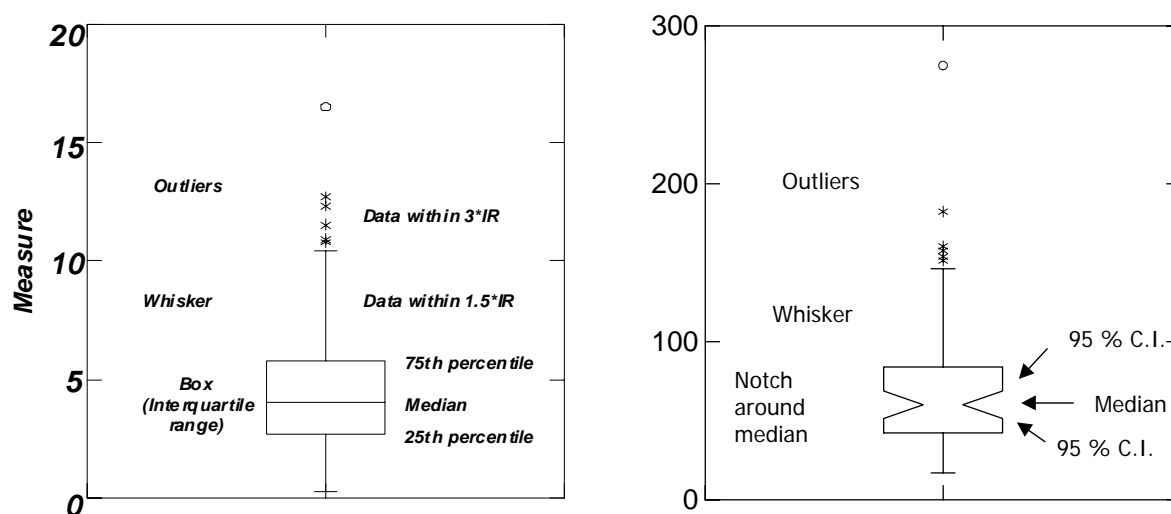


Figure 3-4. Illustration of box whisker plots and notched box whisker plots as defined by SYSTAT statistical software.

Annual average concentrations of air toxics from 2005 were also compared with concentrations from a study in 1994/1995 by (Zielinska et al., 1998). Measurements were made at the Supersite for a year (roughly spring 1994 through spring 1995). When comparing two data sets measured a decade apart, it is important to consider that the measurements were from different sampling and analytical methods with different detection limits, different sampling intervals, and different months; therefore, these comparisons should be considered qualitative. The most dramatic difference from the 1994/1995 time period compared with 2005 is that benzene concentrations at the Supersite have decreased by more than a factor of three (from roughly 7.7 $\mu\text{g}/\text{m}^3$ to near 2 $\mu\text{g}/\text{m}^3$). This drop is consistent with efforts over the past decade to reduce benzene in gasoline, paint, and other consumer products. Carbon tetrachloride concentrations have been shown to decline at roughly 10 ppt per year, and the 2005 measurements reflect this reduction compared to the 1994/1995 concentrations. Formaldehyde concentrations are similar between the two time periods while acetaldehyde concentrations in 2005 are significantly lower than a decade ago.

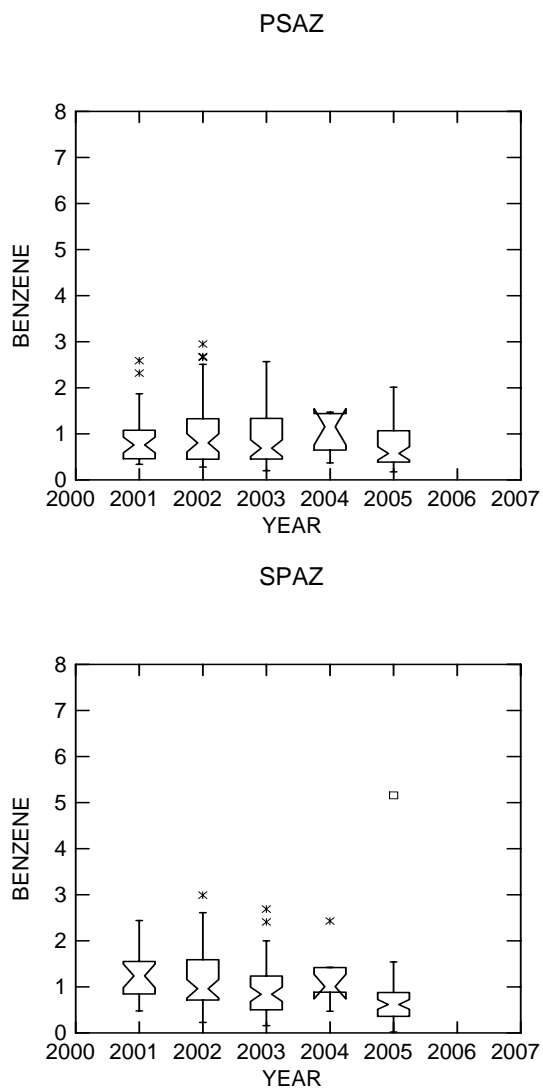


Figure 3-5. Twenty-four hour average concentrations by year at the Supersite (PSAZ) and South Phoenix (SPAZ) site from 2001 through 2005.

4. SUMMARY OF RESULTS

The JATAP is a consortium of federal, state, local, and tribal air pollution control officials designed to address the risk from air toxics in the greater Phoenix Metropolitan area. Participants include U.S. Environmental Protection Agency (EPA) Region 9, the EPA OAQPS, ADEQ, the Maricopa County Environmental Services Division, the Pinal County Air Quality Control District, the Intertribal Council of Arizona, the Gila River Indian Community, the Salt River–Pima Maricopa Indian Community, and the Fort McDowell Yavapai Nation. The purpose of the study is to determine which air toxics are of most concern to South Phoenix and tribal communities. The measurements made in 2005 were the second phase of the study. Phase I consisted of air toxics measurements at the South Phoenix and West 43rd Avenue sites from August 2001 through March 2004 ((McCarthy et al., 2004a)). The ultimate goal of this consortium is to obtain a metropolitan-wide assessment of the risk associated with airborne toxics in greater Phoenix. Validation and analysis of the gaseous air toxics data collected during the 2005 JATAP field project focused on four questions:

1. Can air toxics data be used to assess risk in the Phoenix area?
2. Which species were identified as the most important contributors to risk?
3. What are the likely sources of air toxics in the Phoenix area?
4. How do concentrations of air toxics in the Phoenix area compare with other urban areas and to important health benchmarks?

In addressing these questions, the following conclusions and recommendations were made based on the air toxics data collected at the JATAP sites.

Can air toxics data be used to assess risk in the Phoenix area?

- Data quality appeared reasonable and concentrations of two-thirds of the species at all sites were above detection limits most of the time. The amount of data above detection in 2005 was improved over 2004 because of generally lower detection limits. We noted that interlaboratory comparisons and collocated measurements indicate that JATAP concentrations collected at multiple sites may be biased low.
- Pollutants for which we have modest to good confidence in estimating risk at most sites using 2005 JATAP data included carbon tetrachloride, acetaldehyde, benzene, dichloromethane, and formaldehyde.

How do concentrations of air toxics in the Phoenix area compare with other urban areas and to important health benchmarks?

- Phoenix area urban concentrations of 1,3-butadiene, acetaldehyde, formaldehyde, chloroform, benzene, and tetrachloroethene were typically on the high end of the national urban scale (i.e., above the 75th percentile). Other air toxics concentrations were typically

within the interquartile range of national concentrations (25th to 75th percentile) (Figure 4-1).

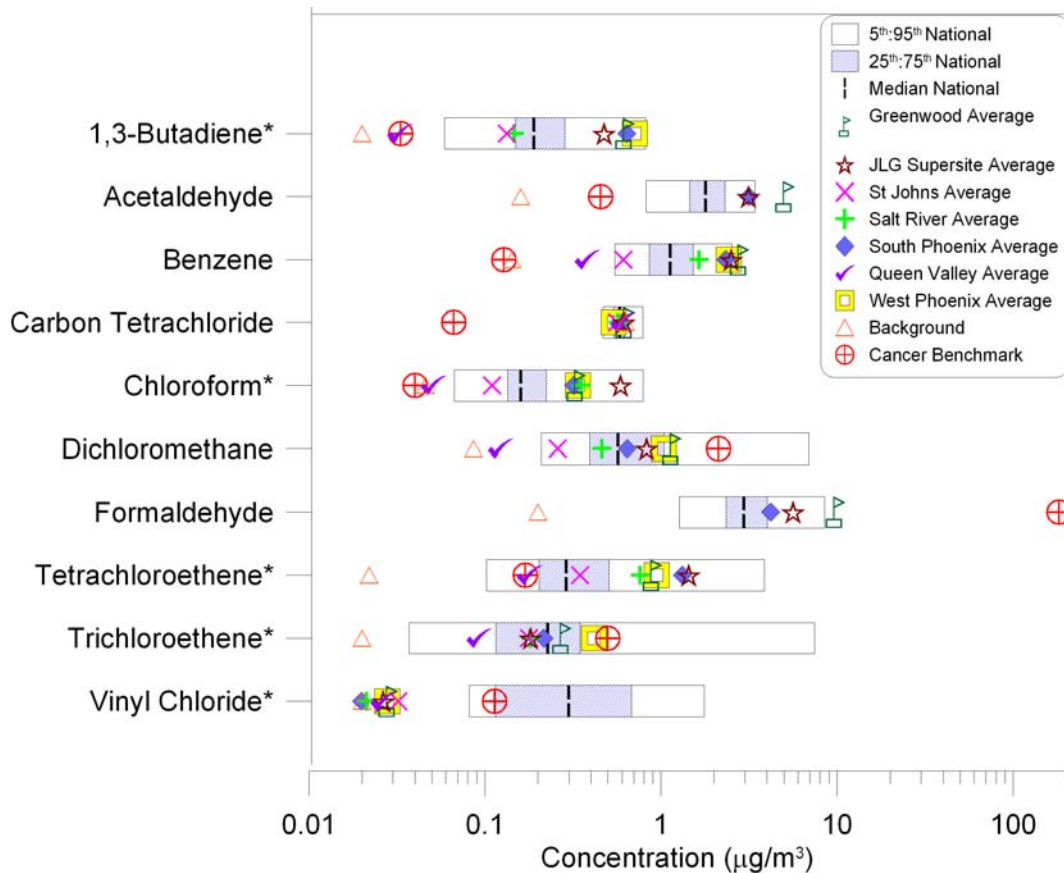


Figure 4-1. Annual average concentrations at JATAP sites compared with national concentration ranges, background concentrations, and cancer benchmarks. Species with an asterisk (*) indicate $\geq 50\%$ of data are below the MDL at some sites.

- Greenwood carbonyl compound concentrations were higher than those at other sites and were above the national 95th percentile. This finding may indicate additional fresh emissions at a local scale, likely from the nearby mobile sources extremely close to the monitor. Carbonyl compound concentrations at South Phoenix and JLG Supersite were also high relative to other urban areas (i.e., above the 75th percentile).
- Concentrations at JATAP sites in 2005 were typically above remote background concentrations, as expected. Air toxics concentrations at Queen Valley were lowest among the sites, consistent with its location far from the urban area. Air toxics concentrations at St. Johns, and sometimes at the Senior Center, were also typically on the lower end of the concentration ranges. Typical remote background concentrations contributed less than 10% of the total concentrations measured at the urban JATAP sites (Greenwood, Supersite, South Phoenix, and West Phoenix).

- Benzene concentrations at the Supersite decreased between 1995 and 2005 by more than a factor of three (from $7.7 \mu\text{g}/\text{m}^3$ to near $2 \mu\text{g}/\text{m}^3$). This drop is consistent with efforts over the past decade to reduce benzene in gasoline, paint, and other consumer products. Carbon tetrachloride concentrations have been shown to decline at roughly 10 ppt per year (McCarthy et al., 2006), and the 2005 measurements reflect this reduction compared with the 1994/1995 concentrations. Formaldehyde concentrations are similar between the two time periods while acetaldehyde concentrations in 2005 are significantly lower than a decade ago.

Which species were identified as the most important contributors to risk? What are the likely sources of air toxics in the Phoenix area?

- Annual mean concentrations of air toxics concentrations at JATAP sites were often higher than the one-in-a-million cancer benchmark. 1,3-butadiene, acetaldehyde, benzene, carbon tetrachloride, chloroform, and tetrachloroethene were well above the one-in-a-million risk level. These pollutants are emitted by mobile sources (1,3-butadiene, benzene), are formed in the atmosphere through reactions of other volatile organic compounds (acetaldehyde), are due to global background (carbon tetrachloride), and come from solvent use and other sources (chloroform, tetrachloroethene). However, concentrations of 1,3-butadiene, acetaldehyde, benzene, carbon tetrachloride and chloroform in urban areas in the United States are typically above the cancer benchmark.
- Some species that are not monitored are considered important contributors to risk or health hazard (e.g., acrolein, arsenic, chromium VI, particulate organic matter [POM]). Of the 10 air toxics identified by the 1999 NATA as most important to inhalation cancer risk, ethylene dibromide and 1,1,2,2-tetrachloroethane were monitored for but were below detection while bis(2-ethylhexyl)phthalate, naphthalene, and ethylene dichloride are not currently monitored.
- For the JATAP sites, acetaldehyde, benzene, dichloromethane, and trichloroethene typically agreed within a factor of two of the 1999 NATA model results consistent with national level comparisons of model and monitor data. Ethylbenzene-, formaldehyde-, and tetrachloroethylene-monitored concentrations at the JATAP sites were more than a factor of two higher than model estimates.

5. RECOMMENDATIONS

As this second phase of JATAP ends, several tasks are yet to be performed according to the original JATAP blueprint, including emission inventory development, urban airshed modeling of air toxics, risk assessment, and communication of risk to the general population. The work performed in this project—analysis of air toxics collected as part of the JATAP 2005—leads to additional recommendations for further research:

- Part of this work included exploring the use of source apportionment with the air toxics data. Exploratory analysis using positive matrix factorization (PMF) showed that there was an insufficiently large matrix of air toxics samples and other species to obtain meaningful results. However, STI's recent work with EPA exploring multiple pollutant source apportionment indicates that it may be useful to perform source apportionment on a large data set of combined air toxics and speciated PM_{2.5}, such as that available from the Supersite from 2000-2005.
- This work focused on gaseous air toxics. Validation and analysis of speciated PM_{2.5} data collected at the Supersite should be performed. This site has an especially rich record of data including data from the national networks, STN and IMPROVE. Particulate toxics can be important in terms of risk in urban areas, and the PM_{2.5} data could be placed in a broader national context: how do toxics metals fit into the national picture? Are concentrations above benchmarks?
- Another area of concern to the air toxics community is diesel particulate matter (DPM), which was not examined in this work. Aethalometer™ black carbon measurement occurring at the Supersite can help us better understand DPM: . Validation and analysis of Aethalometer data from the Supersite should be performed with the goal of better understanding the importance of DPM.
- A formal analysis of spatial variability could be performed to statistically compare concentrations and the coefficient of variation by pollutant among the sites. However, in qualitative review of the data, the Supersite appears to be fairly representative of most of the other urban sites, indicating that some of the other urban sites may be redundant. The Greenwood site was very interesting in that concentrations of many pollutants were higher at this site, likely due to its proximity to the freeways. The concentrations at the West and South Phoenix sites were similar to each other and to those at the Supersite, indicating that these sites may not be as important to maintain in the future. For the more rural sites, Queen Valley continues to be useful as a remote site, but concentrations of air toxics are very low and often below detection. While the measurements provide information, ADEQ may want to work with EPA and others to consider ways to lower the detection limits to improve data quality at the low concentration sites (e.g., longer duration samples). The tribal land sites are different from each other and show some features different from Queen Valley, indicating that retaining these sites may be important.
- The air toxics data collected during JATAP 2005 are sufficient to perform a risk assessment screening.

- Analyses focused on the air toxics with cancer benchmarks; however, further exploration of species with noncancer benchmarks, ozone precursors, and chlorofluorocarbons could be made, including trends over time and spatial variability.
- For the Supersite, trends in air toxics should be compared with trends in criteria pollutants and known emission control programs to assess whether control programs targeting criteria and other pollutants may have a beneficial multipollutant effect, including on air toxics.

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APPENDIX A

LIST OF FLAGGED SAMPLES

Data validation, when done well, is labor intensive. To assess the validity of the data, we inspected a time series plot of every species, prepared numerous scatter plots, including a plot of every species and species group versus the total mass, and inspected the fingerprint plot of every sample. Whole samples are flagged as suspect only if a large percentage of above MDL species shows suspicious concentrations or temporal variability. Individual species are flagged as suspect when problems are noted. In some cases, the samples may have an analytical error that needs to be corrected, may have a sampling problem that was inadvertently missed, or may just appear odd. A review of the data by ADEQ or EAS may indicate that some suspect data are invalid, some data need to be reprocessed and re-reported, and other data remain suspect (cause unknown). These suspect samples remain flagged in our working database, and in this report, for the attention of data analysts.

Table A-1 lists the samples and individual VOCs collected at the JATAP sites in 2005 that were flagged as suspect or noted as having potential problems, **Table A-2** lists the missing or invalid samples from the JATAP sites in 2005, and **Table A-3** lists average minimum detection limits for species collected at JATAP sites in 2005.

Table A-1. Samples collected at JATAP sites in 2005 that were flagged by STL.

Sample Date	QC Code ^a	Species ^b	Comment
Greenwood			
8/2/2005	7	Formaldehyde	below background concentration
8/8/2005	7	Formaldehyde	below background concentration
Senior Center			
3/11/2005	7	Sample	final pressure < 5 psi
South Phoenix			
2/3/2005	8	Sample	channel never came on, no air to canister
1/4/2005	7	Formaldehyde, Acetaldehyde	below background concentration
1/28/2005	7	Chloroform, Carbon tetrachloride	spike, probably real, not typical
2/15/2005	7	Sample	final pressure < 5 psi
2/21/2005	7	Tetrachloroethene	spike
3/5/2005	7	Sample	final pressure -1 psi
3/11/2005	7	Sample	final pressure < 5 psi
4/16/2005	7	Sample	dip, initial canister pressure of -22 in Hg
4/22/2005	7	Sample	final pressure 1.5 psi
5/10/2005	7	Sample	final pressure 2 psi
5/28/2005	7	Sample	final pressure -1 psi
6/9/2005	7	Sample	final pressure 2 psi
8/2/2005	7	Sample	dip all species, power outage
10/1/2005	7	Toluene	toluene:benz outlier, low compared to benz
11/12/2005	7	Sample	dip all species, below background
11/30/2005	7	Sample	final pressure 0 psi
West Phoenix			
10/7/2005	8	Sample	final canister pressure < 5 psi, canister broken
2/15/2005	7	Sample	initial canister pressure of -20 in Hg; collocated analysis discrepancies
3/17/2005	7	Sample	line to canister was loose, final canister pressure < 5 psi; collocated analysis discrepancies
4/22/2005	7	Sample	final canister pressure 1 psi
8/27/2005	7	Sample	collocated analysis discrepancies
10/13/2005	7	Sample	final canister pressure 2 psi
10/25/2005	7	Sample	actual run time unknown, removal flow rate not in acceptable range.
10/31/2005	7	Sample	final pressure < 5 psi
12/12/2005	7	Sample	final pressure negative.
12/18/2005	7	Sample	final pressure negative.
12/30/2005	7	Sample	final pressure 0 psi

^a QC Code = Flag code. A flag of 7 indicates a suspect species record, 8 indicates an invalid record, 9 indicates a species record that has been designated as missing, and "note" is a species record that could have potential issues.

^b Species = A designation of the individual hydrocarbon or the entire sample record to which the flag applies.

Table A-2. Missing or invalid samples from JATAP sites in 2005.

Site	Date of Expected Sample	Sample Type	Reason Sample is Missing or Invalid
Greenwood	December 30, 2005	Cartridge	no sample taken
Senior Center	January 4, 2005	Canister	no sample taken
South Phoenix	January 10, 2005	Cartridge	sample flow rate out of limits
South Phoenix	January 19, 2005	Cartridge	sample flow rate out of limits
South Phoenix	February 3, 2003	Canister	no air to canister
South Phoenix	July 15, 2005	Canister	voided by EAS lab
South Phoenix	July 21, 2005	Canister	make up run on July 24
South Phoenix	October 19, 2005	Cartridge	sample flow rate out of limits
South Phoenix	November 24, 2005	Cartridge	sample flow rate out of limits
South Phoenix	November 30, 2005	Cartridge	sample flow rate out of limits
South Phoenix	December 6, 2005	Cartridge	sample flow rate out of limits
South Phoenix	December 12, 2005	Cartridge	lost
South Phoenix	December 18, 2005	Cartridge	sample flow rate out of limits
South Phoenix	December 24, 2005	Cartridge	sample flow rate out of limits
Supersite	January 10, 2005	Cartridge	sample flow rate out of limits
Supersite	January 16, 2005	Cartridge	sample flow rate out of limits
Supersite	January 28, 2005	Cartridge	sample flow rate out of limits
Supersite	February 9, 2005	Cartridge	sample flow rate out of limits
Supersite	October 25, 2005	Cartridge	sample flow rate out of limits
Supersite	November 24, 2005	Cartridge	sample flow rate out of limits
Supersite	November 30, 2005	Cartridge	sample flow rate out of limits
Supersite	December 6, 2005	Cartridge	sample flow rate out of limits
Supersite	December 12, 2005	Cartridge	sample flow rate out of limits
Supersite	December 12, 2005	Cartridge	sample flow rate out of limits
Supersite	December 18, 2005	Cartridge	sample flow rate out of limits
Supersite	December 24, 2005	Cartridge	sample flow rate out of limits
West Phoenix	January 4, 2005	Canister	canister not analyzed
West Phoenix	October 7, 2005	Canister	canister broken

Table A-3. Average minimum detection limits for species collected at JATAP sites in 2005.

Method	AQS Code	Parameter	Average MDL (ppb)
TO-15	43218	1,3-Butadiene	0.10
TO-15	43844	Hexachlorobutadiene	0.42
TO-15 SIM	43802	Dichloromethane	0.03
TO-15 SIM	43803	Chloroform	0.03
TO-15 SIM	43804	Carbon tetrachloride	0.04
TO-15 SIM	43815	1,2-Dichloroethane	0.03
TO-15 SIM	43817	Tetrachloroethene	0.06
TO-15 SIM	43819	Bromomethane	0.02
TO-15 SIM	43824	Trichloroethene	0.06
TO-15 SIM	43826	1,1-Dichloroethene	0.02
TO-15 SIM	43829	1,2-Dichloropropane	0.04
TO-15 SIM	43860	Vinyl chloride	0.02
TO-15 SIM	45109	m & p-Xylene	0.06
TO-15 SIM	45201	Benzene	0.03
TO-15 SIM	45202	Toluene	0.04
TO-15 SIM	45203	Ethylbenzene	0.04
TO-15 SIM	45204	o-Xylene	0.04
TO-15 SIM	45207	1,3,5-Trimethylbenzene	0.03
TO-15 SIM	45208	1,2,4-Trimethylbenzene	0.03
TO-15 SIM	45220	Styrene	0.06

APPENDIX B

DATA VALIDATION DETAILS BY SITE FOR 2005

Data Validation: Greenwood

The Greenwood site ambient carbonyl compound data for 2005 had no major issues. On August 2 and August 8, 2005, formaldehyde concentrations were flagged as suspect because the concentrations were below typical background concentrations as shown in **Figure B-1**.

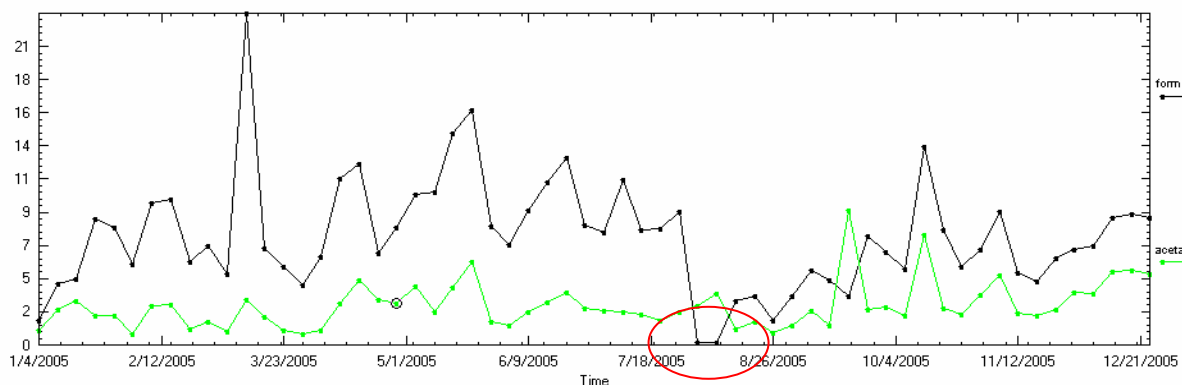


Figure B-1. Low concentrations (ppb) in formaldehyde (form) (here shown with acetaldehyde – aceta) at Greenwood on August 2 and August 8, 2005, were flagged as suspect.

Data Validation: Senior Center

For Senior Center, the 12-hr morning and evening samples were inspected individually and then averaged to create 24-hr average data for further validation. We made the following observations of the ambient 2005 Senior Center data:

- Higher than usual dichloromethane concentrations seen in **Figure B-2** on April 22, May 4, and December 24, 2005, were noted but not flagged.
- A spike in tetrachloroethene concentration shown in **Figure B-3** on March 29, 2005, was noted but not flagged.

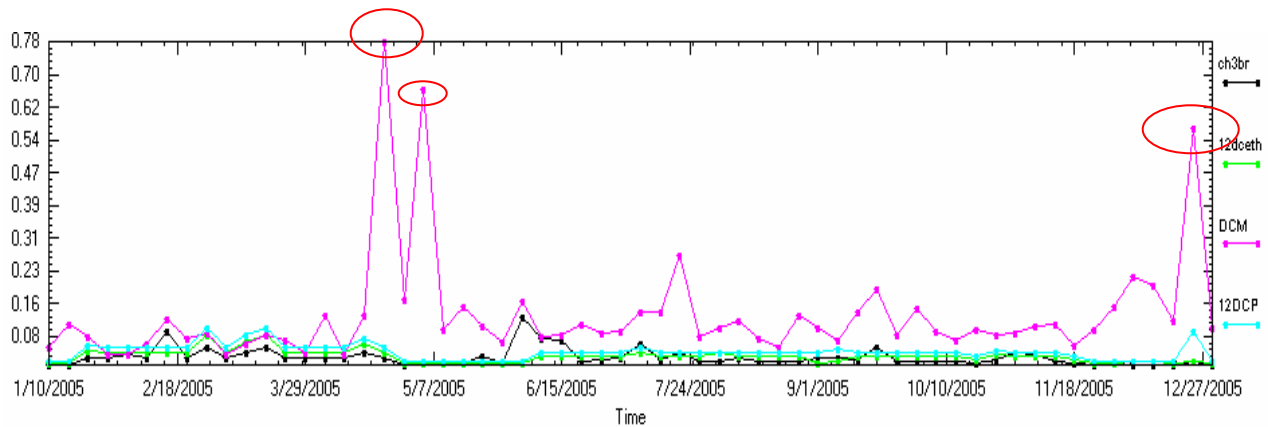


Figure B-2. Time series of toxics concentrations (ppb) at the Senior Center site. High dichloromethane (DCM) concentrations on April 22, May 4, and December 24, 2005, are circled in red.

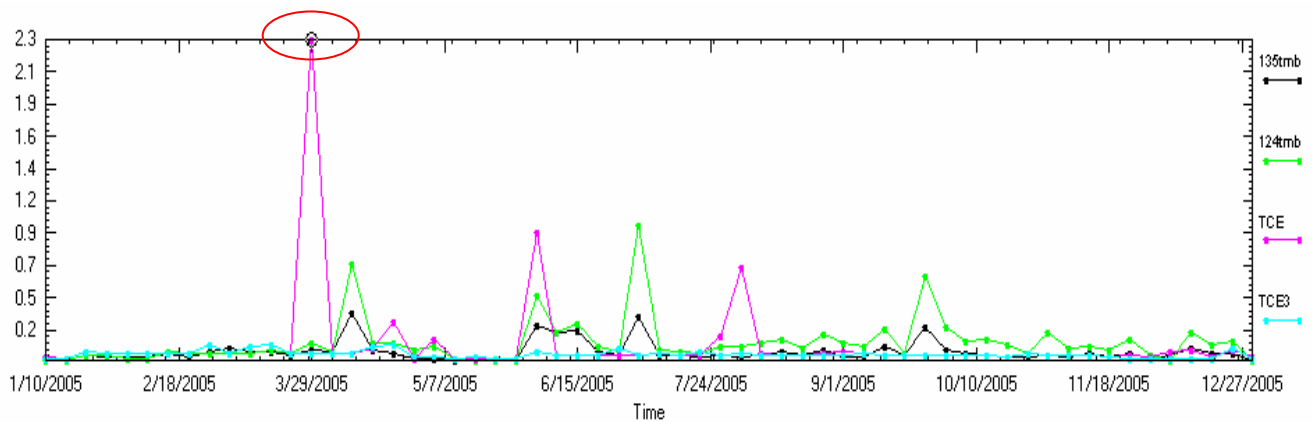


Figure B-3. Time series of toxics concentrations (ppb) at the Senior Center site. A high tetrachloroethene (TCE) concentration on March 29, 2005, is circled in red.

Data Validation: South Phoenix

The 2005 ambient South Phoenix air toxics data can be characterized by several specific issues and observations:

- A spike in tetrachloroethene concentration on February 21, 2005, shown in **Figure B-4**, was flagged as suspect. The concentration is a factor of 40 greater than the average tetrachloroethene concentration at the site.
- Spikes that occurred in chloroform and carbon tetrachloride concentrations on January 28, 2005, were flagged as suspect. The concentrations are possibly real, but not typical.

- Eight samples were flagged as suspect because the final pressure of the canisters was below the acceptable final pressure of 5 psi. Most of these samples cannot be differentiated from those with acceptable final pressures; however, these data should be used with caution.

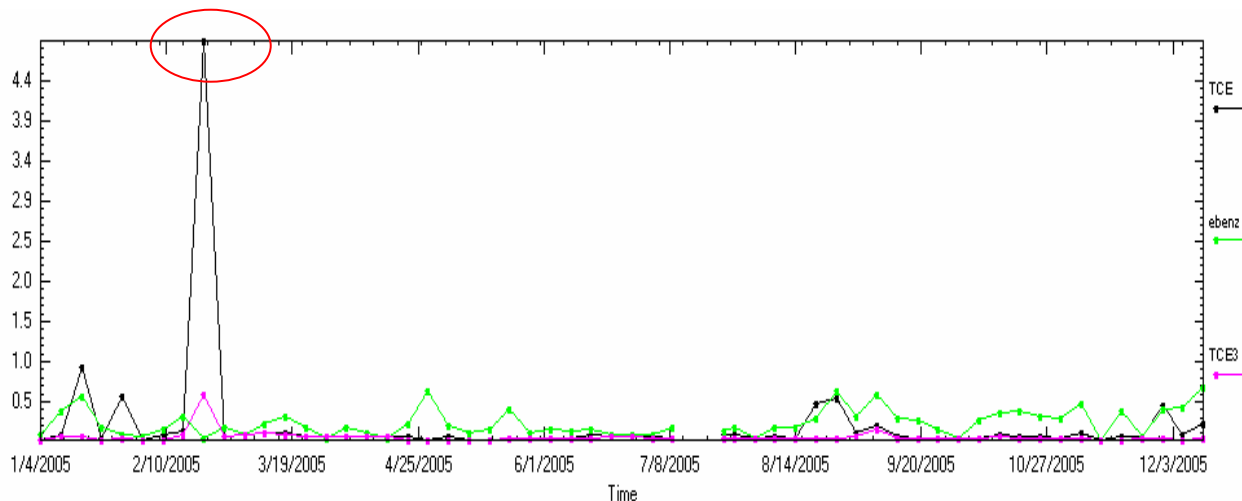


Figure B-4. Time series of tetrachloroethene (TCE), ethylbenzene (ebenz), and trichloroethene (TCE3) concentrations (ppb) at South Phoenix. The high concentration for TCE (circled in red) on February 21, 2005 was flagged as suspect.

The South Phoenix 2005 carbonyl compound data were analyzed by the SDAPCD. The flow rates of 12 samples were lower than acceptable limits and were, therefore, flagged as invalid by laboratory analysts. The reduced flow was caused by a clogged needle valve used to maintain flow rate during sample collection; this sampling problem has been addressed by SDAPCD in its more recent sampling equipment supplied to ADEQ. Cartridge samples that do not meet accepted flow rates are invalidated because concentrations of these samples are calculated by dividing a mass of analyte by the volume of air flowing through the cartridge; flow rates beyond acceptable limits mean a concentration cannot be calculated with any certainty.

Data Validation: JLG Supersite

The JLG Supersite ambient carbonyl compound data for 2005 were analyzed by the SDAPCD. The only issue with samples collected at this site was that the flow rates of 12 samples were lower than accepted limits and were therefore flagged as invalid by the laboratory; the same problem occurred at the South Phoenix site for carbonyl compound samples.

Data Validation: West Phoenix

Specific issues with respect to the West Phoenix ambient 2005 data were noted:

- Eight samples were flagged as suspect because the final pressure of the canisters was below the acceptable final pressure of 5 psi. Most of these samples cannot be

differentiated from those with acceptable final pressures; however, these data should be used with caution.

- Spikes in toluene and trichloroethene concentrations on February 21, 2005, shown in **Figure B-5**, were noted. These species were not flagged; however, these concentrations were not typical. We speculate that these spikes may be due to nearby solvent use.
- A high concentration sample of dichloromethane on June 9, 2005, was noted but not flagged.

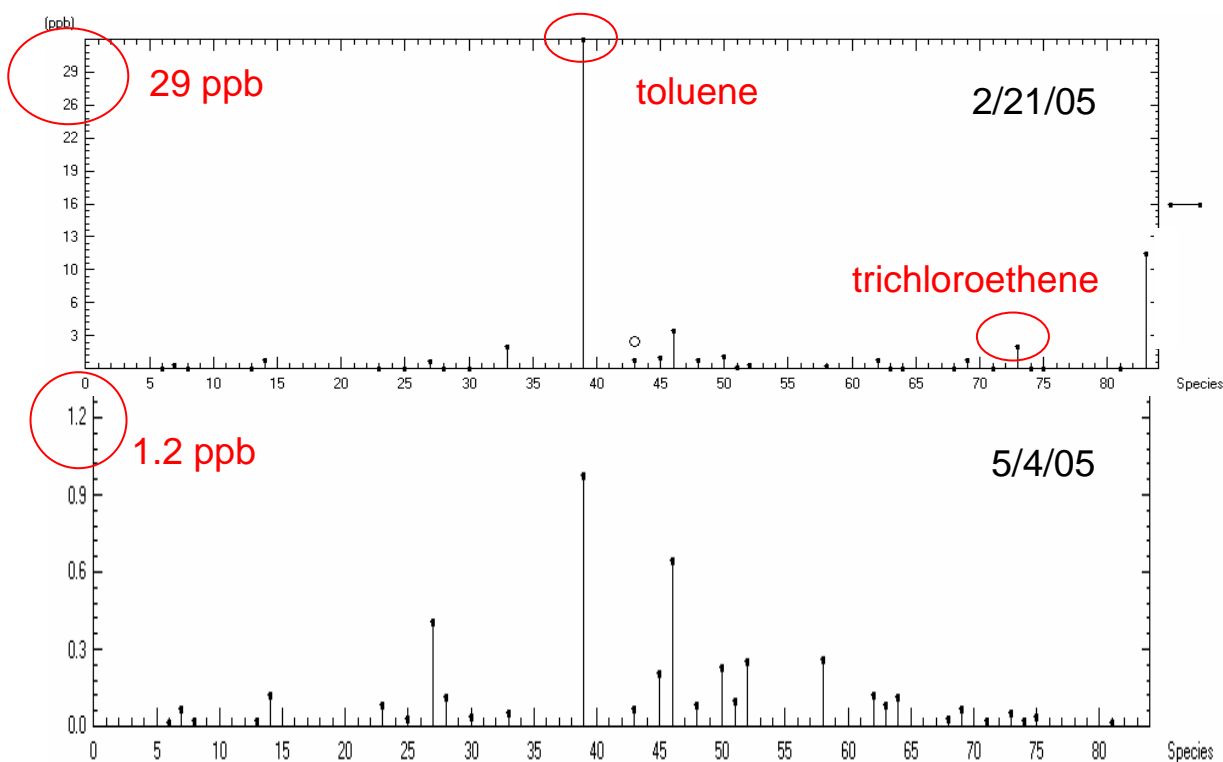


Figure B-5. Comparison of fingerprint plots of data collected at the West Phoenix site on two days. The fingerprint plot on February 21, 2005, (top) shows significantly higher concentrations of toluene and trichloroethene concentrations (ppb) compared to typical concentrations as illustrated on May 4, 2005 (bottom).

APPENDIX C

LIST OF SELECTED SPECIES AND THEIR EMISSIONS SOURCES.

Species	Likely Emission Sources	Comments
acetaldehyde	Key photochemical reaction product. Also produced from fuel combustion (diesel?). Intermediate in synthesis of other chemicals (e.g., perfumes, polyester resins, and basic dyes); fruit and fish preservative and flavoring agent; also a solvent in rubber, tanning, and paper industries.	Secondary source from degradation of other volatile organic compounds (VOCs); most likely to correlate with formaldehyde
benzene	Constituent in motor fuels. Also present in fuel combustion processes, refining, and solvents.	Tracer for vehicle exhaust; significantly reduced since 1995 with the introduction of reformulated gasoline.
1,3-butadiene	Petroleum refining, motor vehicle exhaust, production of rubber and plastics/copolymers. Also from forest fires and cigarette smoke.	Likely to correlate with benzene and other mobile source tracer species.
carbon tetrachloride	Completely phased out of production in 2000 by Clean Air Act Title VI. Limited uses expected in the United States post-2000. Was used as an intermediate for production of CFCs/freons (refrigerants), propellants, solvents, landfill disposal, grain fumigant, dry cleaning agent. Only industrial uses remain; no fumigant or commercial uses.	Very long lifetime in the atmosphere. Concentrations do not vary much site to site on multi-year basis.
chloroform	Solvent for adhesives, pesticides, fats, oils, and rubbers. Used in pharmaceutical manufacturing and to make hydrochlorofluorocarbons (HCFC-22). By-product of chlorination from drinking water plants (and swimming pools?) and wood pulp chlorination.	Past uses: extraction of solvents, dry cleaning spot remover, fire extinguishers, fumigant, anesthetic – no longer used for these products.
formaldehyde	Key photochemical reaction product. Also produced by power plants, manufacturing facilities, incinerators, and automobile exhaust emissions. Used as a chemical intermediate, analytical reagent, concrete and plaster additives, cosmetics, disinfectants, fumigants, photography, and wood preservation; urea-formaldehyde resins and particle board products.	Secondary source from degradation of other VOCs; most likely to correlate with acetaldehyde. Urea-formaldehyde insulating material phased out in 1982.
dichloromethane (aka methylene chloride)	Common solvent, agent in urethane foam blowing propellant, electroplating, and the paint industry; aerospace manufacturing and de-icing.	May have been used in semiconductor industry.

Species	Likely Emission Sources	Comments
1,2-dichloropropane (<i>aka propylene chloride</i>)	Chemical intermediate in production of chlorinated organic chemicals; industrial solvent; ion exchange; toluene diisocyanate production; photographic film manufacture; paper coating; petroleum catalyst regeneration; soil fumigant; and degreaser.	Pesticide formulations containing 1,2-dichloropropane are no longer available. Concentrations are typically below MDL at most sites.
perchloroethylene (<i>aka tetrachloroethylene</i>)	Dry cleaning and textile processing; chemical intermediate; vapor degreasing in metal cleaning operations.	Chemical residence time in the atmosphere of a few months. Concentrations tend to correlate with population density.
trichloroethylene	Solvent degreasing, dry cleaning, chemical intermediate, and refrigerant. Consumer products (paint remover, adhesives, spot removers, rug-cleaning fluid).	Was used as a general anesthetic. Often (>50%) below MDL in national studies.
vinyl chloride	Chemical and plastics industry (polyvinyl chloride [PVC] precursor) used in furniture and car upholstery, wall coverings; housewares and automotive parts refrigerant. Landfills and waste water treatment may release vinyl chloride.	Almost entirely (>90%) below MDL in national studies.

APPENDIX D

TOP FIVE 24-HR CONCENTRATIONS IN 2005 BY POLLUTANT AND SITE

Table D-1. The five highest 24-hour concentrations ($\mu\text{g}/\text{m}^3$) at each JATAP site in 2005 compared to Arizona Ambient Air Quality Guidelines (AAAQG). Values \geq AAAQG are in bold.

Page 1 of 4

Species	Greenwood 24-hr ($\mu\text{g}/\text{m}^3$)	JLG Supersite 24-hr ($\mu\text{g}/\text{m}^3$)	Queen Valley 24-hr ($\mu\text{g}/\text{m}^3$)	St. Johns 24-hr ($\mu\text{g}/\text{m}^3$)	Salt River 24-hr ($\mu\text{g}/\text{m}^3$)	South Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	West Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	AAAQG 24-hr ($\mu\text{g}/\text{m}^3$)
1,3-Butadiene	1.7 1.3 1.3 1.3 1.2	1.5 1.4 1.1 1.1 1.1	0.09 0.09 0.09 0.08 0.08	0.9 0.5 0.3 0.3 0.3	1.0 0.7 0.5 0.4 0.3	3.8 3.3 2.7 2.1 1.9	2.9 2.7 2.5 2.1 2.1	1.9
Acetaldehyde	17.3 14.1 10.7 9.6 9.4	5.8 8.8 4.8 4.7 4.5	a	a	a	15.3 5.8 5.4 4.8 4.7	a	1400
Benzene	6.7 6.2 5.6 5.5 5.2	6.6 5.9 5.5 5.0 5.0	0.6 0.4 0.4 0.4 0.4	1.6 1.4 1.3 1.3 1.2	23.2 18.3 9.1 8.5 2.1	17.0 5.1 4.9 4.3 4.2	8.0 7.7 6.4 5.9 5.5	51
Carbon tetrachloride	0.8 0.7 0.7 0.7 0.7	0.7 0.7 0.7 0.7 0.7	0.8 0.7 0.7 0.7 0.7	1.2 1.0 0.9 0.8 0.8	1.0 0.9 0.9 0.9 0.8	5.6 1.1 0.9 0.9 0.9	0.9 0.9 0.8 0.8 0.8	13
Chloroform	0.8 0.6 0.6 0.6 0.6	1.7 1.5 1.4 1.4 1.3	0.1 0.1 0.1 0.1 0.1	0.3 0.2 0.2 0.2 0.2	0.9 0.9 0.9 0.7 0.6	4.9 1.0 0.8 0.6 0.5	1.7 1.0 0.8 0.7 0.6	16

Table D-1. The five highest 24-hour concentrations ($\mu\text{g}/\text{m}^3$) at each JATAP site in 2005 compared to Arizona Ambient Air Quality Guidelines (AAAQG). Values \geq AAAQG are in bold.

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Species	Greenwood 24-hr ($\mu\text{g}/\text{m}^3$)	JLG Supersite 24-hr ($\mu\text{g}/\text{m}^3$)	Queen Valley 24-hr ($\mu\text{g}/\text{m}^3$)	St. Johns 24-hr ($\mu\text{g}/\text{m}^3$)	Salt River 24-hr ($\mu\text{g}/\text{m}^3$)	South Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	West Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	AAAQG 24-hr ($\mu\text{g}/\text{m}^3$)
Dichloromethane	4.0 4.0 3.1 2.7 2.4	2.4 1.9 1.8 1.7 1.7	0.2 0.2 0.2 0.2 0.2	1.4 1.3 0.7 0.5 0.5	2.8 2.4 2.0 1.0 0.8	3.0 1.9 1.7 1.3 1.3	6.0 3.2 2.7 2.6 2.3	2000
Ethylbenzene	4.7 4.7 4.6 4.6 4.2	4.3 4.0 4.0 3.6 3.6	0.5 0.4 0.4 0.4 0.4	1.4 1.2 1.1 1.0 0.9	6.0 5.4 1.7 1.4 1.4	3.0 2.9 2.8 2.8 2.6	6.1 5.5 4.6 3.5 3.3	3500
Formaldehyde	29.0 20.6 18.5 17.3 16.4	9.6 9.0 8.2 7.6 7.5	a	a	a	7.1 7.0 6.6 6.0 6.0	a	12
Hexachlorobutadiene	0.4 0.3	0.6 0.4	b	b	b	b	b	1.9
m,p-Xylene	13.8 11.8 11.4 10.7 10.5	11.2 9.5 9.4 9.1 8.3	1.1 1.0 1.0 1.0 1.0	4.6 3.3 2.1 2.1 2.0	14.3 5.2 4.9 4.8 4.3	9.1 8.5 8.4 7.8 7.6	16.7 9.5 9.0 8.8 8.7	3500

Table D-1. The five highest 24-hour concentrations ($\mu\text{g}/\text{m}^3$) at each JATAP site in 2005 compared to Arizona Ambient Air Quality Guidelines (AAAQG). Values \geq AAAQG are in bold.

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Species	Greenwood 24-hr ($\mu\text{g}/\text{m}^3$)	JLG Supersite 24-hr ($\mu\text{g}/\text{m}^3$)	Queen Valley 24-hr ($\mu\text{g}/\text{m}^3$)	St. Johns 24-hr ($\mu\text{g}/\text{m}^3$)	Salt River 24-hr ($\mu\text{g}/\text{m}^3$)	South Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	West Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	AAAQG 24-hr ($\mu\text{g}/\text{m}^3$)
o-Xylene	5.1 4.7 4.4 4.3 4.1	4.0 3.8 3.6 3.4 3.4	0.6 0.5 0.5 0.5 0.5	1.6 1.5 0.8 0.8 0.8	6.2 2.7 2.6 2.0 1.8	3.3 3.2 3.0 2.9 2.6	5.6 3.4 3.0 3.0 2.9	3500
Styrene	4.6 4.5 4.5 4.2 3.8	2.9 1.9 1.4 1.4 1.3	0.5 0.5 0.4 0.4 0.4	2.2 2.1 1.4 1.3 1.3	6.8 4.7 4.5 3.9 3.4	2.5 2.3 0.9 0.8 0.8	3.5 3.5 3.4 3.0 3.0	1700
Tetrachloroethene	8.4 3.3 2.4 1.7 1.7	5.5 4.4 4.2 4.0 3.5	0.5 0.4 0.3 0.3 0.2	2.3 2.1 1.7 1.5 0.7	8.1 6.6 4.8 2.0 1.4	6.3 3.9 3.8 3.4 3.3	6.2 2.0 2.0 1.4 1.2	770
Toluene	26.3 20.0 19.3 18.5 18.1	18.4 18.2 16.0 15.3 15.1	1.5 1.1 1.0 1.0 0.9	9.7 9.4 8.3 5.4 4.5	62.8 40.6 37.1 29.0 25.1	28.4 18.6 15.8 15.7 14.3	124 21.9 21.8 21.0 20.0	3000
Trichloroethene	1.7 0.6 0.6 0.5 0.5	0.5 0.4 0.4 0.4 0.3	0.2 0.2 0.2 0.2 0.2	1.0 0.9 0.7 0.2 0.2	0.7 0.5 0.4 0.4 0.4	3 0.7 0.5 0.4 0.3	12 0.5 0.4 0.4 0.4	280

Table D-1. The five highest 24-hour concentrations ($\mu\text{g}/\text{m}^3$) at each JATAP site in 2005 compared to Arizona Ambient Air Quality Guidelines (AAAQG). Values \geq AAAQG are in bold.

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Species	Greenwood 24-hr ($\mu\text{g}/\text{m}^3$)	JLG Supersite 24-hr ($\mu\text{g}/\text{m}^3$)	Queen Valley 24-hr ($\mu\text{g}/\text{m}^3$)	St. Johns 24-hr ($\mu\text{g}/\text{m}^3$)	Salt River 24-hr ($\mu\text{g}/\text{m}^3$)	South Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	West Phoenix 24-hr ($\mu\text{g}/\text{m}^3$)	AAAQG 24-hr ($\mu\text{g}/\text{m}^3$)
Vinyl chloride	0.13	b	b	0.27 0.19 0.09 0.09 0.07	0.04 0.01	0.04 0.02	0.06 0.02	4.4

^aMeasured at Greenwood, JLG Supersite, and South Phoenix only.

^bBelow detection limit.

APPENDIX E

SUMMARY STATISTICS FOR 2005 BY SITE AND POLLUTANT

Table E1. Summary statistics for Greenwood in 2005.

Page 1 of 2

SITE	GWAZ	GWAZ	GWAZ	GWAZ	GWAZ	GWAZ	GWAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
1,1,2,2-Tetrachloroethane	59	0.011	0.010	0.010	0.020	0.002	0.02
1,1,2-Trichloroethane	59	0.010	0.010	0.010	0.010	0.000	0.02
1,1-Dichloroethane	59	0.010	0.010	0.010	0.010	0.000	0.02
1,1-Dichloroethene	59	0.011	0.010	0.010	0.048	0.005	0.02
1,2,4-Trichlorobenzene	59	0.046	0.010	0.010	0.192	0.057	0.02
1,2,4-Trimethylbenzene	59	0.496	0.406	0.010	1.069	0.275	0.02
1,2-Dichlorobenzene	59	0.014	0.010	0.010	0.096	0.015	0.02
1,2-Dichloroethane	59	0.017	0.010	0.010	0.091	0.013	0.02
1,2-Dichloropropane	59	0.010	0.010	0.010	0.010	0.000	0.02
1,3,5-Trimethylbenzene	59	0.187	0.169	0.010	0.362	0.068	0.02
1,3-Butadiene	59	0.273	0.234	0.035	0.763	0.149	0.02
1,3-Dichlorobenzene	59	0.015	0.010	0.010	0.107	0.018	0.02
1,4-Dichlorobenzene	59	0.131	0.120	0.010	0.244	0.044	0.02
Acetaldehyde	60	2.728	2.410	0.740	9.290	1.598	0.20
Benzene	59	0.844	0.731	0.203	2.023	0.435	0.02
Benzyl Chloride	59	0.012	0.010	0.010	0.157	0.019	0.02
Bromoform	59	0.012	0.010	0.010	0.032	0.005	0.02
Bromomethane	59	0.014	0.010	0.005	0.060	0.011	0.02
Carbon Tetrachloride	59	0.097	0.097	0.068	0.115	0.010	0.02
Chlorobenzene	59	0.013	0.010	0.010	0.035	0.006	0.02
Chloroethane	59	0.020	0.010	0.010	0.066	0.014	0.02
Chloroform	59	0.066	0.056	0.010	0.149	0.033	0.02
Chloromethane	59	0.435	0.449	0.250	0.566	0.073	0.02
Cis-1,2-Dichloroethene	59	0.014	0.010	0.010	0.266	0.033	0.02
Cis-1,3-Dichloropropylene	59	0.016	0.010	0.010	0.123	0.020	0.02
Dichlorodifluoromethane	59	0.447	0.454	0.093	0.842	0.108	0.02
Dichloromethane	59	0.321	0.228	0.056	1.107	0.245	0.02
Ethylbenzene	59	0.457	0.355	0.115	1.049	0.265	0.02
Ethylene Dibromide	59	0.011	0.010	0.010	0.040	0.007	0.02
Formaldehyde	60	7.479	6.893	0.071	22.871	3.895	0.15
Freon 113	59	0.067	0.067	0.042	0.087	0.011	0.02
Freon 114	59	0.014	0.014	0.010	0.020	0.002	0.02
Hexachlorobutadiene	59	0.010	0.010	0.010	0.035	0.003	0.02
Isoprene	59	0.461	0.389	0.119	1.130	0.289	0.02
M,P-Xylene	59	1.211	1.115	0.114	3.066	0.678	0.02
Methyl Chloroform	59	0.024	0.024	0.009	0.069	0.010	0.02
Methyl Ethyl Ketone	59	0.728	0.717	0.050	1.597	0.328	0.02
Methyl Tert-Butyl Ether	59	0.010	0.010	0.010	0.010	0.000	0.02
M-Xylene	59	0.831	0.775	0.104	2.062	0.467	0.02
O-Xylene	59	0.464	0.377	0.083	1.130	0.265	0.02

Table E1. Summary statistics for Greenwood in 2005.

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SITE	GWAZ	GWAZ	GWAZ	GWAZ	GWAZ	GWAZ	GWAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
P-Ethyltoluene	59	0.213	0.188	0.010	0.456	0.100	0.02
P-Xylene	59	0.381	0.332	0.010	1.004	0.214	0.02
Styrene	59	0.390	0.286	0.010	1.035	0.249	0.02
Tetrachloroethene	59	0.128	0.090	0.024	1.196	0.165	0.02
Toluene	59	2.266	1.858	0.234	6.766	1.458	0.02
Trans-1,2-Dichloroethylene	59	0.013	0.010	0.010	0.177	0.022	0.02
Trans-1,3-Dichloropropylene	59	0.014	0.010	0.010	0.106	0.016	0.02
Trichloroethene	59	0.049	0.042	0.010	0.309	0.041	0.02
Trichlorofluoromethane	59	0.311	0.283	0.220	1.405	0.152	0.02
Vinyl Chloride	59	0.011	0.010	0.010	0.050	0.005	0.02

Table E2. Summary statistics for JLG Supersite in 2005.

Page 1 of 2

SITE	PSAZ	PSAZ	PSAZ	PSAZ	PSAZ	PSAZ	PSAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
1,1,2,2-Tetrachloroethane	55	0.011	0.010	0.010	0.023	0.003	0.02
1,1,2-Trichloroethane	55	0.010	0.010	0.010	0.026	0.002	0.02
1,1-Dichloroethane	55	0.010	0.010	0.010	0.010	0.000	0.02
1,1-Dichloroethene	55	0.010	0.010	0.010	0.010	0.000	0.02
1,2,4-Trichlorobenzene	55	0.018	0.010	0.009	0.120	0.010	0.02
1,2,4-Trimethylbenzene	55	0.393	0.304	0.105	0.948	0.221	0.02
1,2-Dichlorobenzene	55	0.027	0.010	0.010	0.076	0.022	0.02
1,2-Dichloroethane	55	0.013	0.010	0.009	0.032	0.006	0.02
1,2-Dichloropropane	55	0.010	0.010	0.010	0.010	0.000	0.02
1,3,5-Trimethylbenzene	55	0.161	0.153	0.085	0.262	0.074	0.02
1,3-Butadiene	55	0.207	0.149	0.048	0.647	0.089	0.02
1,3-Dichlorobenzene	55	0.027	0.010	0.010	0.090	0.024	0.02
1,4-Dichlorobenzene	55	0.185	0.174	0.076	0.426	0.152	0.02
Acetaldehyde	49	1.688	1.700	0.700	3.100	0.581	0.10
Benzene	55	0.758	0.576	0.176	2.011	0.459	0.02
Benzyl Chloride	55	0.010	0.010	0.010	0.010	0.000	0.02
Bromoform	55	0.012	0.010	0.001	0.033	0.007	0.02
Bromomethane	55	0.013	0.010	0.010	0.032	0.005	0.02
Carbon Tetrachloride	55	0.095	0.100	0.038	0.114	0.015	0.02
Chlorobenzene	55	0.012	0.010	0.010	0.026	0.004	0.02
Chloroethane	55	0.017	0.010	0.010	0.047	0.018	0.02
Chloroform	55	0.117	0.105	0.019	0.329	0.071	0.02
Chloromethane	55	0.448	0.454	0.268	0.636	0.081	0.02
Cis-1,2-Dichloroethene	55	0.010	0.010	0.010	0.010	0.000	0.02
Cis-1,3-Dichloropropylene	55	0.015	0.010	0.010	0.103	0.003	0.02
Dichlorodifluoromethane	55	0.460	0.467	0.204	0.623	0.424	0.02
Dichloromethane	55	0.231	0.171	0.038	0.669	0.150	0.02
Ethylbenzene	55	0.359	0.246	0.094	0.960	0.233	0.02
Ethylene Dibromide	55	0.012	0.010	0.010	0.040	0.007	0.02
Formaldehyde	49	4.424	4.300	2.200	7.600	1.170	0.10
Freon 113	55	0.067	0.067	0.048	0.086	0.010	0.02
Freon 114	55	0.015	0.014	0.003	0.020	0.028	0.02
Hexachlorobutadiene	55	0.011	0.010	0.010	0.054	0.007	0.02
Isoprene	55	0.433	0.326	0.073	1.069	0.297	0.02
M,P-Xylene	55	0.964	0.662	0.230	2.486	0.602	0.02
Methyl Chloroform	55	0.028	0.028	0.010	0.046	0.007	0.02
Methyl Ethyl Ketone	55	1.372	1.276	0.050	3.274	1.234	0.02
Methyl Tert-Butyl Ether	55	0.011	0.010	0.010	0.067	0.008	0.02
M-Xylene	55	0.658	0.446	0.142	1.779	0.084	0.02
O-Xylene	55	0.360	0.240	0.104	0.881	0.181	0.02

Table E2. Summary statistics for JLG Supersite in 2005.

Page 2 of 2

SITE	PSAZ	PSAZ	PSAZ	PSAZ	PSAZ	PSAZ	PSAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
P-Ethyltoluene	55	0.179	0.169	0.010	0.385	0.173	0.02
P-Xylene	55	0.306	0.219	0.088	0.721	0.033	0.02
Styrene	55	0.174	0.143	0.038	0.520	0.047	0.02
Tetrachloroethene	55	0.205	0.155	0.025	0.782	0.082	0.02
Toluene	55	1.845	1.174	0.270	4.716	0.525	0.02
Trans-1,2-Dichloroethylene	55	0.010	0.010	0.010	0.010	0.000	0.02
Trans-1,3-Dichloropropylene	55	0.016	0.010	0.010	0.088	0.017	0.02
Trichloroethene	55	0.033	0.028	0.010	0.093	0.019	0.02
Trichlorofluoromethane	55	0.295	0.290	0.228	0.383	0.220	0.02
Vinyl Chloride	55	0.010	0.010	0.010	0.010	0.000	0.02

Table E3. Summary statistics for Queen Valley in 2005.

Page 1 of 2

SITE	QVAZ	QVAZ	QVAZ	QVAZ	QVAZ	QVAZ	QVAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
1,1,2,2-Tetrachloroethane	30	0.011	0.010	0.010	0.020	0.002	0.02
1,1,2-Trichloroethane	30	0.011	0.010	0.010	0.022	0.003	0.02
1,1-Dichloroethane	30	0.010	0.010	0.010	0.010	0.000	0.02
1,1-Dichloroethene	30	0.010	0.010	0.010	0.010	0.000	0.02
1,2,4-Trichlorobenzene	30	0.027	0.010	0.010	0.140	0.037	0.02
1,2,4-Trimethylbenzene	30	0.078	0.084	0.010	0.151	0.037	0.02
1,2-Dichlorobenzene	30	0.019	0.010	0.010	0.057	0.016	0.02
1,2-Dichloroethane	30	0.012	0.010	0.010	0.030	0.005	0.02
1,2-Dichloropropane	30	0.011	0.010	0.010	0.027	0.003	0.02
1,3,5-Trimethylbenzene	30	0.032	0.010	0.010	0.131	0.042	0.02
1,3-Butadiene	30	0.014	0.010	0.010	0.040	0.010	0.02
1,3-Dichlorobenzene	30	0.015	0.010	0.010	0.059	0.013	0.02
1,4-Dichlorobenzene	30	0.037	0.010	0.010	0.092	0.033	0.02
Benzene	30	0.115	0.112	0.084	0.174	0.018	0.02
Benzyl Chloride	30	0.010	0.010	0.010	0.010	0.000	0.02
Bromoform	30	0.012	0.010	0.010	0.030	0.005	0.02
Bromomethane	30	0.012	0.010	0.010	0.020	0.003	0.02
Carbon Tetrachloride	30	0.094	0.098	0.054	0.121	0.015	0.02
Chlorobenzene	30	0.012	0.010	0.010	0.022	0.003	0.02
Chloroethane	30	0.036	0.038	0.010	0.080	0.019	0.02
Chloroform	30	0.010	0.010	0.001	0.023	0.006	0.02
Chloromethane	30	0.412	0.425	0.273	0.550	0.070	0.02
Cis-1,2-Dichloroethene	30	0.010	0.010	0.010	0.010	0.000	0.02
Cis-1,3-Dichloropropylene	30	0.010	0.010	0.010	0.010	0.000	0.02
Dichlorodifluoromethane	30	0.431	0.437	0.049	0.545	0.101	0.02
Dichloromethane	30	0.034	0.035	0.010	0.067	0.015	0.02
Ethylbenzene	30	0.077	0.076	0.010	0.100	0.020	0.02
Ethylene Dibromide	30	0.012	0.010	0.010	0.038	0.007	0.02
Freon 113	30	0.068	0.068	0.047	0.086	0.011	0.02
Freon 114	30	0.015	0.015	0.010	0.021	0.003	0.02
Hexachlorobutadiene	30	0.010	0.010	0.010	0.010	0.000	0.02
Isoprene	30	0.116	0.106	0.010	0.414	0.110	0.02
M,P-Xylene	30	0.182	0.181	0.020	0.241	0.044	0.02
Methyl Chloroform	30	0.019	0.023	0.004	0.028	0.007	0.02
Methyl Ethyl Ketone	30	1.058	1.032	0.050	4.070	0.814	0.02
Methyl Tert-Butyl Ether	30	0.012	0.010	0.010	0.056	0.008	0.02
M-Xylene	30	0.101	0.105	0.010	0.158	0.022	0.02
O-Xylene	30	0.084	0.086	0.010	0.125	0.034	0.02
P-Ethyltoluene	30	0.014	0.010	0.010	0.073	0.015	0.02
P-Xylene	30	0.081	0.076	0.010	0.112	0.027	0.02
Styrene	30	0.024	0.010	0.002	0.118	0.034	0.02

Table E3. Summary statistics for Queen Valley in 2005.

Page 2 of 2

SITE	QVAZ	QVAZ	QVAZ	QVAZ	QVAZ	QVAZ	QVAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
Tetrachloroethene	30	0.026	0.024	0.010	0.076	0.014	0.02
Toluene	30	0.166	0.151	0.096	0.391	0.065	0.02
Trans-1,2-Dichloroethylene	30	0.010	0.010	0.010	0.010	0.000	0.02
Trans-1,3-Dichloropropylene	30	0.010	0.010	0.010	0.010	0.000	0.02
Trichloroethene	30	0.017	0.010	0.010	0.041	0.010	0.02
Trichlorofluoromethane	30	0.258	0.265	0.212	0.324	0.024	0.02
Vinyl Chloride	30	0.010	0.010	0.010	0.010	0.000	0.02

Table E4. Summary statistics for St. Johns in 2005.

SITE	SJAZ	SJAZ	SJAZ	SJAZ	SJAZ	SJAZ	SJAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
1,1-Dichloroethene	58	0.016	0.011	0.005	0.113	0.017	0.02
1,2,4-Trimethylbenzene	58	0.088	0.064	0.006	0.618	0.105	0.02
1,2-Dichloroethane	58	0.019	0.020	0.010	0.076	0.010	0.03
1,2-Dichloropropane	58	0.016	0.016	0.008	0.103	0.013	0.04
1,3,5-Trimethylbenzene	58	0.054	0.032	0.008	0.419	0.071	0.03
1,3-Butadiene	58	0.058	0.039	0.035	0.380	0.057	0.09
Benzene	58	0.185	0.156	0.062	0.479	0.092	0.02
Bromoethane	58	0.034	0.013	0.005	0.389	0.060	0.02
Carbon tetrachloride	58	0.087	0.086	0.012	0.180	0.029	0.03
Chloroform	58	0.022	0.018	0.006	0.072	0.012	0.02
Dichloromethane	58	0.072	0.056	0.018	0.396	0.069	0.03
Ethylbenzene	58	0.082	0.063	0.012	0.305	0.071	0.03
Hexachlorobutadiene	58	0.205	0.148	0.130	0.660	0.114	0.41
M,P-Xylene	58	0.196	0.157	0.018	1.030	0.178	0.05
O-Xylene	58	0.081	0.068	0.013	0.362	0.069	0.03
Styrene	58	0.079	0.041	0.009	0.489	0.102	0.06
Tetrachloroethene	58	0.050	0.028	0.013	0.322	0.065	0.05
Toluene	58	0.646	0.525	0.088	2.484	0.488	0.03
Trichloroethene	58	0.032	0.026	0.013	0.191	0.033	0.05
Vinyl chloride	58	0.012	0.008	0.004	0.108	0.016	0.02

Table E5. Summary statistics for Salt River (Senior Center) in 2005.

SITE	SRAZ	SRAZ	SRAZ	SRAZ	SRAZ	SRAZ	SRAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
1,1-Dichloroethene	60	0.013	0.010	0.005	0.051	0.008	0.02
1,2,4-Trimethylbenzene	60	0.139	0.101	0.006	0.977	0.170	0.02
1,2-Dichloroethane	60	0.016	0.016	0.008	0.040	0.007	0.03
1,2-Dichloropropane	60	0.021	0.020	0.010	0.082	0.012	0.04
1,3,5-Trimethylbenzene	60	0.067	0.046	0.008	0.350	0.074	0.03
1,3-Butadiene	60	0.064	0.035	0.035	0.450	0.069	0.08
Benzene	60	0.500	0.212	0.087	7.027	1.175	0.02
Bromoethane	60	0.021	0.013	0.005	0.124	0.021	0.02
Carbon tetrachloride	60	0.088	0.091	0.023	0.159	0.030	0.04
Chloroform	60	0.070	0.063	0.015	0.186	0.039	0.02
Dichloromethane	60	0.128	0.095	0.018	0.778	0.136	0.03
Ethylbenzene	60	0.158	0.099	0.018	1.322	0.220	0.03
Hexachlorobutadiene	60	0.173	0.130	0.130	0.680	0.088	0.35
M,P-Xylene	60	0.409	0.278	0.051	3.199	0.450	0.05
O-Xylene	60	0.177	0.121	0.020	1.382	0.198	0.04
Styrene	60	0.446	0.411	0.009	1.552	0.293	0.06
Tetrachloroethene	60	0.109	0.033	0.013	2.317	0.325	0.05
Toluene	60	1.858	0.918	0.144	16.156	2.790	0.04
Trichloroethene	60	0.033	0.026	0.013	0.121	0.020	0.05
Vinyl chloride	60	0.008	0.008	0.004	0.020	0.004	0.02

Table E6. Summary statistics for South Phoenix in 2005.

SITE	SPAZ	SPAZ	SPAZ	SPAZ	SPAZ	SPAZ	SPAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
1,1-Dichloroethene	59	0.010	0.010	0.005	0.027	0.004	0.02
1,2,4-Trimethylbenzene	59	0.238	0.131	0.006	1.644	0.303	0.02
1,2-Dichloroethane	59	0.015	0.016	0.008	0.035	0.006	0.03
1,2-Dichloropropane	59	0.019	0.020	0.010	0.044	0.007	0.04
1,3,5-Trimethylbenzene	59	0.094	0.072	0.008	0.639	0.101	0.03
1,3-Butadiene	59	0.280	0.160	0.035	1.640	0.332	0.10
Acetaldehyde	52	1.695	1.500	0.020	8.200	1.093	0.10
Benzene	59	0.706	0.619	0.021	5.158	0.690	0.02
Bromoethane	59	0.025	0.013	0.005	0.279	0.039	0.02
Carbon tetrachloride	59	0.093	0.081	0.009	0.856	0.106	0.03
Chloroform	59	0.063	0.041	0.006	0.979	0.127	0.02
Dichloromethane	59	0.179	0.137	0.024	0.833	0.145	0.03
Ethylbenzene	59	0.248	0.184	0.010	0.663	0.177	0.03
Formaldehyde	52	3.310	3.350	0.015	5.600	1.106	0.10
Hexachlorobutadiene	59	0.226	0.145	0.130	0.660	0.170	0.44
M,P-Xylene	59	0.771	0.618	0.018	2.030	0.542	0.05
O-Xylene	59	0.268	0.201	0.010	0.736	0.194	0.03
Styrene	59	0.090	0.070	0.009	0.575	0.102	0.05
Tetrachloroethene	59	0.189	0.057	0.013	4.913	0.647	0.05
Toluene	59	1.763	1.351	0.021	7.295	1.428	0.03
Trichloroethene	59	0.039	0.026	0.013	0.582	0.074	0.05
Vinyl chloride	59	0.008	0.008	0.004	0.018	0.003	0.02

Table E7. Summary statistics for West Phoenix in 2005.

SITE	WPAZ	WPAZ	WPAZ	WPAZ	WPAZ	WPAZ	WPAZ
Species	Number of cases	Mean (ppbv)	Median (ppbv)	Minimum	Maximum	Standard Dev	Average MDL
1,1-Dichloroethene	59	0.015	0.010	0.005	0.176	0.023	0.03
1,2,4-Trimethylbenzene	59	0.292	0.215	0.006	3.069	0.434	0.04
1,2-Dichloroethane	59	0.023	0.016	0.008	0.281	0.040	0.05
1,2-Dichloropropane	59	0.026	0.020	0.010	0.351	0.044	0.06
1,3,5-Trimethylbenzene	59	0.131	0.092	0.008	1.357	0.187	0.05
1,3-Butadiene	59	0.311	0.185	0.035	1.270	0.302	0.11
Benzene	58	0.736	0.600	0.440	2.419	0.537	0.03
Bromoethane	59	0.026	0.016	0.005	0.176	0.030	0.03
Carbon tetrachloride	59	0.083	0.076	0.013	0.316	0.043	0.05
Chloroform	59	0.067	0.050	0.006	0.346	0.056	0.03
Dichloromethane	59	0.290	0.223	0.018	1.676	0.265	0.04
Ethylbenzene	59	0.528	0.205	0.014	13.319	1.717	0.05
Hexachlorobutadiene	59	0.265	0.130	0.130	1.675	0.287	0.49
M,P-Xylene	59	1.080	0.634	0.018	7.986	1.239	0.07
O-Xylene	59	0.374	0.237	0.014	1.813	0.354	0.05
Styrene	59	0.186	0.084	0.009	1.005	0.239	0.08
Tetrachloroethene	59	0.135	0.066	0.013	2.012	0.281	0.08
Toluene	59	3.306	1.860	0.023	31.936	5.777	0.05
Trichloroethene	59	0.075	0.028	0.013	2.127	0.278	0.08
Vinyl chloride	59	0.011	0.008	0.004	0.140	0.018	0.03